NAVAL FACILITIES ENGINEERING SERVICE CENTER
Port Hueneme, California 93043-4370

Contract Report
CR 96.014

AMPHIBIOUS CARGO BEACHING (ACB) LIGHTER DEVELOPMENT - PHASE I

An Investigation Conducted by

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October 1996

REPORT DOCUMENTATION PAGE				*Form Approved* *OMB No. 0704-018*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE October 1996		3. REPORT TYPE AND DATES COVERED May 1995 to Jan 1996	
4. TITLE AND SUBTITLE **Amphibious Cargo Beaching (ACB) Lighter Development -- Phase I (Book 2 of 2)**			5. FUNDING NUMBERS PE - 62233N Contract No. N47408-95-C-0202	
6. AUTHOR(S) Kvaerner Masa Marine Inc 201 Defense Highway Suite 202 Annapolis, MD 21401				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSE(S) Naval Facilities Engineering Service Center Port Hueneme CA 93043-4370			8. PERFORMING ORGANIZATION REPORT NUMBER **CR 96.014**	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESSES Office of Naval Research Arlington VA 22217-5000			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE	

13. ABSTRACT *(Maximum 200 words)*

This report documents a conceptual design effort for the Amphibious Cargo Beaching (ACB) Lighter, a modular barge system which is being developed to replace the Navy Lighter (NL) pontoon causeway system. The ACB Lighter will be rapidly deployed from an auxiliary crane ship and be assembled and operated in sea conditions through sea state three to support Joint Logistics Over the Shore (JLOTS) operations. Results are presented for three major sub-phases of study: (1) technology review to establish state-of-the-art and identify new and emerging technologies of direct application to ACB Lighter development; (2) platform requirements review to establish the constraints and conditions imposed through various mission operations with an objective of providing a set of general limitations of criteria to guide design; and (3) preliminary design including review of options for module forms, analysis of module response and operational performance, initial definition of structural requirements, and identification of module outfit conditions. The report presents a recommended concept for continued development.

14. SUBJECT TERMS Amphibious Cargo Beaching (ACB) Lighter, Navy Lighter (NL), Joint Logistics Over the Shore (JLOTS), pontoon, module, barge, causeway			15. NUMBER OF PAGES 413 16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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1.0 INTRODUCTION

This document contains and describes the results of a research effort relating to the development of an Amphibious Cargo Beaching (ACB) Lighter. This research has been performed under Contract N47408-95-C-0202, sponsored by the Naval Facilities Engineering Service Center (NFESC).

The ACB system concept is based on an attempt to enhance the operability of over the shore cargo operations. At present this mission is met with the Navy's Lighter Causeway System (NL). Elements of the NL system, which is a mature design, do not allow safe operations in sea conditions beyond Sea State 2. Also, the configuration of the present NL lighterage requires them to be limited to transport on the deck or hatch cover of a ship or side loaded on an LST class ship. The LST is being phased out, and stacking of lighterage on the deck of cargo ships limits the number of units that can be carried. The concept for the ACB system, which is proposed to replace the NL system, stems from two underlying premises:

- extending the window of operations into Sea State 3 conditions will significantly improve the usefulness of the system,
- providing a transportation configuration that is based on ISO container modularity will greatly increase the options for transport.

The scope of effort for this Phase I of the development of the ACB system has focused on providing information and engineering sufficient to generate a description of the system modules to a "Concept Design" level. The baseline for the concept development has been a general description of a system provided by NFESC of an ISO compatible configuration. This baseline effectively provided limits on dimensions, weight, and on certain operational characteristics.

The effort presented in this report covers three major sub-phases of work. The first was a Technology Review which involved a review of the state-of-the-art with an aim of identifying new and emerging technologies in modular platforms which might have application for the ACB.

The second sub-phase was a Platform Requirements Review which focused on developing a full understanding of the requirements placed on the ACB system by various mission operations. The objective was to provide a set of general limitations or criteria to guide the design process.

The last sub-phase involved the design work itself and included reviewing options for module forms, analysis of module response and operational performance, initial definition of structural requirements, and identification of module outfit requirements.

2.0 TECHNOLOGY REVIEW

As the first set of tasks within the ACB development process, the Technology Review was intended to provide a review of the state-of-the-art of modular platform technology. The objective of this review was to identify new and emerging technologies that may be of interest and/or might find applicability in the ACB development.

The review process focused on undertaking searches to identify sources of potentially relevant information and following up on positive responses. The search efforts extended to commercial sources, academic sources, and research facilities. Additionally technical literature searches were undertaken using technical periodicals, the in-house technical library , and the local academic library as well as part of the follow-up process where specific research, felt to be relevant, was identified.

Table 2.1 shows the search parameters for the review process, describing contacts as well as the general success of the requests.

The Modular Platform Technology Matrix given in Table 2.2 provides a listing of technology that has been identified in the review. In addition to the name and basic description the technology/system this also gives a description of the information available and/or the applicability to the ACB. Copies of technical information generated from the review are provided in Appendix A. Also in the appendix is a listing of specific references that may be of general interest.

In general, the data developed during this review are either already well known to NFESC or beyond the scope of the ACB Lighter development. Examples of the latter type include the research into large scale floating mat systems such as floating airports as well as semi-submersible floating bridges. Of the technology/systems reported in the Technology Matrix, the most important, from the standpoint of potentially effecting the ACB development process, relate to systems designed to attenuate the motions of floating systems. Several of the sources give excellent information on passive systems that could be easily fitted on any floating system and that are intended to increase the system's damping characteristics. These include the use of simple attachments such as perforated plates or meshes, as found on floating breakwaters and dock systems, as well as the fitting of passive roll stabilization tanks.

Some of the general information for several of the systems reported were of use in making comparisons with design results for the ACB modules. This is particularly true of structural arrangements and scantlings, of which information was made available from several diverse sources.

Other interesting results were derived from systems that suggest alternatives for the hullform concept for the modules, such as those of commercial dock systems.

TABLE 2.1
TECHNOLOGY REVIEW SEARCH PARAMETERS

Name	Contact	Results
Finlay Navigation		Recieved data on BABINE CHARGER
BMT Test tank UK	Bob Holland	Reference to Mississippi Dredger for Army Corps of Engineers. 8 free-to-pivot self aligning barge units. No data found
SSPA Test Tank Sweden	Eric Bjarne	no response
DMI Test Tank Denmark	Fred Pucill	Reference to floating tunnel. No details.
MARIN Test Tank Holland	Gerard Feikema	Reference to Hood Canal Floating Bridge Seattle. No data found
Hydronautics US	Rod Barr	No Response
Marintek Test Tank Norway	Kjell Holden	No Response
Kværner Concrete Constructors	Peter Johnson	No Response
Radisson Design - Floating docks		General data received
Miklos Kossa Naval Architect		Reference to Green Bay pontoons, FLEXIFLOAT, RENDRAG , Neil Lampson pontoons
Atkins UK	Rod Rainey	No Response
IMD Test Tank Newfoundland	Don Spencer	Reference to NRC Hydraulics Lab Ottawa
University of British Columbia	Dr. Sander Calisal	No Response
BC Research Test Tank	Gerry Stensgaard	Reference to Hood Canal Bridge
Memorial University Newfoundland (MUN)	Neil Bose	Reference to research in semi-submersible bridges. General description received
MUN	Don Bass	Reference to research in passive ballast stabilization tanks. Research paper
MUN	Manmoud Haddara	Reference to Dr. Webster Berkely.
NRC Hydraulics Laboratory Ottawa	Wayne Jamieson	Reference to research on floating breakwaters, and floating ferry terminal for Marine Atlantic.
Berkely	Dr. Webster	Reference to research on floating airports. Reference to Hydroelasticity Conference, Trondheim.
Marine Atlantic	David Lewis	Floating Dock Bar Harbour Maine. General data received
Trondheim University	Odd Faltinsen	Hydroelasticity Conference. Papers of floating airports, wave forces on floating structures. Proceedings received
Neil Lampson Inc.	Neil Lampson	General data received
Naiad Marine		Make fin type stabilizers. Not applicable
Flume Stabilization Systems	Frank Sellers	General data on application of passive tanks to barge forms
Green Bay Structural Steel	Gerald Ravet	General data received

TABLE 2.2
MODULAR PLATFORM TECHNOLOGY MATRIX

System	Basic Description	Level of Information/ Applicability
BABINE CHARGER	Articulated Truck Ferry - Northern British Columbia. Self propelled ferry carrying heavy logging trucks. Two modules, 110 ft by 64 ft by 9.5 ft, connected together with 5 permanent hinges.	Full technical description along with some operational information. Documentation in appendix.
Modular Barge System - Green Bay Structural Steel Inc.	Rectangular steel pontoons connected with through bolting. Used on inland dredging projects. 4, 6 and 8 ft deep sections; 30 40 and 50 ft lengths, 10 ft width.	General brochure provided. General data on structural scantlings provided. Documentation in Appendix
Radisson Design	Commercial Dock System. Steel and timber frame, plastic buoyancy units	Brochure provided in appendix.
MEXEFLOTE	Modular Pontoon System with 20 ft by 8 ft by 4.75 ft modules. Similar to existing NL and MCS systems. Used by UK and Canada in logistics operations.	Already known to NFESC
FLEXIFLOAT	Modular Pontoon System. Basis for Army MCS system. Produced by Robishaw and now Lakeshore.	Already known to NFESC
RENDRAG Pontoon System	Modular pontoon system with a double pin connecting system	Already known to NFESC
TIECO floating breakwater	Floating breakwater system with cylindrical steel buoyance tubes and a flat panel deck.	Technical paper relating to system damping characteristics using perforated plate. Copy of paper in appendix.
Bourgon Lafleur floating breakwater	Floating breakwater system, rectangular form.	Technical paper relating to system damping characteristics using expanded mesh.
Bar Harbour Maine floating ferry dock	Floating ferry terminal platform. Five 10 ft diameter tanks 80 ft long. Steel grating type deck.	Technical paper relating system damping research using perforated plates. Damping system not implemented. General discussion of system and copy of papers in appendix.
Floating Airport Systems	Large scale mat type floating system	Research effort relating to analysis of motions of a floating mat. Copies of papers in appendix.
Semi-submersible Floating Bridge Systems	Concept for a bridge design based on a semi-submersible support system to take advantage of superior motions.	Copies of sketches outlining concept in appendix.
Passive Tank Stabilizers	Application of free surface type tanks designed to be tuned to specific motions to attenuate response.	Research paper on tank stabilizers and data from Flume commercial system in appendix.
Modular Barge System - Neil Lampson Inc.	10 ft x 50 ft modular barge sections connected with through bolting. Used on inland heavy transportation and construction projects.	General data included in appendix.

3.0 PLATFORM REQUIREMENTS REVIEW

3.1 General

The second set of tasks for the ACB development was a Platform Requirements Review. This was intended to review aspects of the ACB system mission in an effort to establish criteria and/or general limitations for the conceptual level design of the modules. The results of the review is a set of loosely formatted general design specifications that provide an envelope within which the ACB modules are to be configured and further developed.

Several sources of information have been used to define basic mission requirements and/or limitations on the design. These include:

- information relating to the general philosophy of the ACB system provided by NFESC,
- reference documents provided by NFESC and/or identified during the contract. These are cited where applicable and listed is Section 6 of the document,
- data obtained by the contractor as part Technology Review as identified in Section 2.

The identified Platform Design Requirements and the bases under which they have been developed are provided in the following sections.

3.2 Transportation Configuration

The requirements of the ACB, from a standpoint of Transportation Configuration, result from interfaces that need to be met between the modules and the various ships that will or might transport them to the area where they will be deployed.

The following is an initial list of vessels that can transport the ACB modules:

- Auxiliary Crane Ships (T-ACS),
- standard ISO containerships,
- Maritime Prepositioning Force (MPF) vessels,
- LASH ships,
- SEABEE ships,
- Large Medium Speed RO/RO (LMSR) or Strategic Sealift (T-AKR) Ships.

The basic interface requirements have only been defined for the transport of ACB modules for the T-ACS and container ship scenarios. Limitations or needs of the modules for transport on the other listed ship types have been developed based on a general understanding of the methods of stowage and how these may be expected to impact on the module design.

The concept for transport onboard T-ACS or container ships requires that the modules be placed in standard container cells in a manner similar to that used for stowage of the Navy's

SEASHED system. It is assumed that all the specifics of the stowage operations of the SEASHED will also apply to the ACB modules. Stowage in this manner requires the following of the ACB modules: 25 foot maximum beam, notches on the ends of the modules to interfaces with the container cell guides.

For transport on MPF and RO/RO vessels, the modules would be stacked on deck potentially making use of container deck fitting grids. In the event that container grids are used the module breadth needs to be limited to 24 feet to ensure that a reasonable container loading pattern is not disrupted.

Stowage on LASH or SEABEE ships will require that the modules be carried in the well deck in a stacked configuration.

Transport on ships other than T-ACS or container ships may require that lashing fittings be provided to tie the modules down to the deck of the ship.

All stowage/transport options require that the lowest stacked module be able to withstand a stacking load of modules on top of it. It is assumed that at most 4 modules will be stacked on top of another module.

3.3 Deployment Requirements

3.3.1 Deployment from T-ACS or ISO Container Ships

Deployment from T-ACS and ISO containerships will be by means of standard cranes and 40-foot-container spreaders. The use of these places a limitation on the weight of individual modules of 30 LT (67,200 pounds) which is equivalent to a loaded 40 foot container.

The general requirement for deployment using T-ACS ships is to be able to place a 40 foot module in the water on the port side using the T-ACS cranes (see reference [1]). The cranes have a rated capacity of 30 LT at 121 foot outreach and can retrieve a load from any cell of the T-ACS or from any cell in a container ship moored to starboard. Whether deploying from container cells onboard the T-ACS or using the cranes to deploy from a standard PANAMAX container ship, a 40 foot module can be placed in the water anywhere along the port side of the T-ACS while maintaining 10 foot clearance from the ships side. This is illustrated in Figure 3.1 which shows the load range covered by the two T-ACS cranes. Therefore deployment using the T-ACS ships places no additional limitations on the ACB module design.

3.3.2 Deployment from MPF, RO/RO or Sealift Ships

It is assumed that these vessels will be fitted with class standard single pedestal twin cranes on the centerline. These have a rated capacities of 35 LT at 130 foot radius and 55 LT at

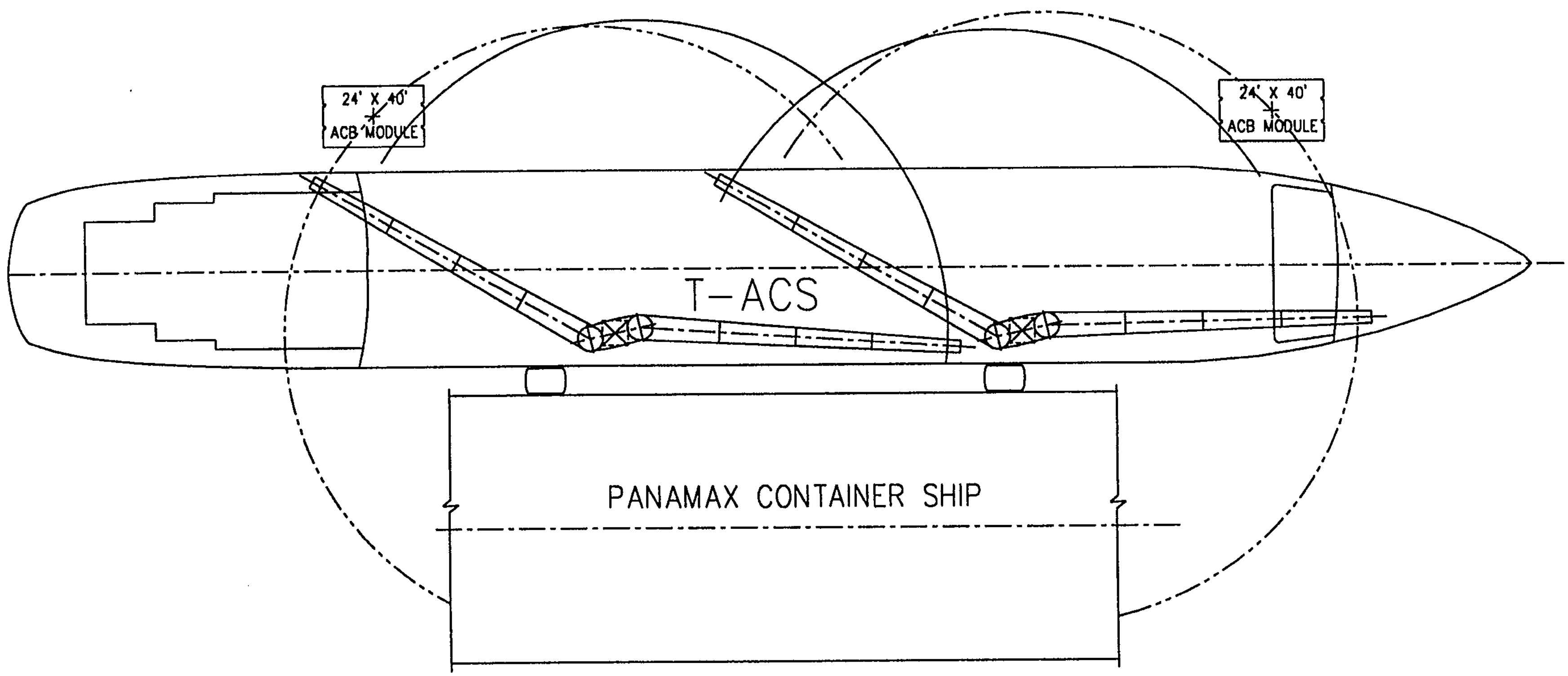


FIGURE 3.1
ACB MODULE DEPLOYMENT WITH T-ACS SHIP

95 foot radius (see reference [2]). Therefore these will place no limitation on the module weight. The 130 foot radius will allow deployment of the modules to either side of the vessel.

3.3.3 Deployment Times

From the standpoint of the ACB design, very little can be modified that would greatly effect the time required to unload, connect and assemble the modules. The physical size and proportions of the module has been defined based on transportation and operational requirements. The connection systems design can and will have an impact on the time to deploy. However this is outside the scope of this study.

The two areas that could influence deployment effort and times are module weights and module motions. In theory if some pre-assembly can be accomplished on the deck of the transport ship then the overall deployment time can be reduced. Pre-assembly would require significant reductions in weight. The following are some scenarios:

- limit module weight so that a 2x40 foot module assembly weighs less than 55 LT which would allow some pre-assembly on the deck of a sealift ship equipped with a class standard sealift crane,
- limit module weight so that a 2x40 foot module assembly weight less that 30 LT which would allow pre-assembly on T-ACS or container ships,
- limit module weight so that a 3x40 foot module assembly weighs less than 55 LT which would allow complete pre-assembly of barge units on the deck of a MPF or Sealift ship.

The feasibility of module weight limitations of these magnitudes will be quickly defined once a first estimate of the modules structure has been made.

Module motions are discussed briefly in Section 3.5.

3.4 Cargo Throughput Operations

3.4.1 Cargo Types and Loading

Reference documentation has been used to develop a list of typical cargoes to be carried by the ACB system. Sources for these include:

- contract kickoff meeting,
- Pontoon System Manual [3],
- T-ACS 4 Class Mission Operations Handbook [1],
- ACB Feasibility Design [4],
- Circular of Requirements for the Design of Strategic Sealift Ships [2].

The cargo types can be roughly divided into three types: containerized, wheeled vehicles, and tracked vehicles. Table 3.1 gives a summary of the characteristics of these cargoes as developed from the reference information including dimensions, weights and footprint loading.

Figures 3.2, 3.3, and 3.4 give sketches of typical loading configurations for the defined cargoes based primarily on cargo dimension limitations, i.e., how many of each type of cargo can be physically placed on a 120 barge assembly with reasonable clearances. Other arrangements are possible, however, without significant reduction in the assumed loading clearances, none are likely to result in a greater load than those shown.

From the Figures it can be seen that the maximum container load would be 175 LT based on carrying 14 - 20 foot containers at an average (nominal) weight of 12.5 LT. This nominal container unit weight is used based on the assumption that the majority of cargo containers are not likely to weigh in at the maximum ISO gross weight. This is supported by information contained in the Circular of Requirements for MPF(E) vessels [5] which uses a nominal design weight for a 20 foot container of 12 LT to determine vessel maximum cargo deadweight. It is assumed that if cargo consists of 20 foot containers at the maximum weight of 20 LT, then fewer in number will be carried. The maximum cargo load overall would be carrying 3 - M1A1 tanks with a total load of 187.5 LT (assuming a weight of an M1A1 tank of 140,000 pounds). Based on this and to allow some margin, a maximum cargo load of 200 LT should be used for performance and stability analyses.

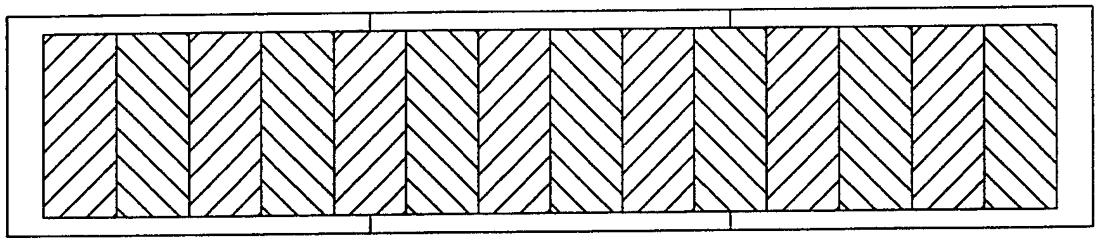
3.4.2 Cargo Operations Interfaces

The ACB Lighter system will replace the existing NL system and will, therefore, be required to provide the same general roles. These include:

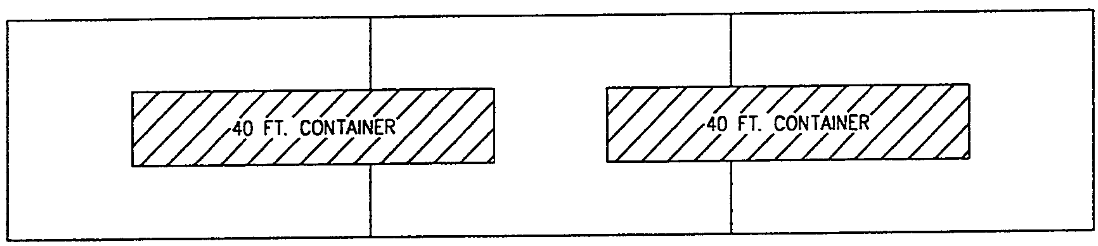
- Lighter/Causeway Ferry,
  - 2 or 3 -120 foot barges linked together and with a powered unit to form a powered lighter or ferry,
  - barge or barge trains operating under tow;
- Causeway,
  - a string of several 120 foot barges anchored in position perpendicular to the beach,
  - it is assumed that the LST-type interface will not be required;
- RO/RO Discharge Facility,
  - 72 ft x 160 ft rigid floating platform made up of 3 wide by 4 long - 40 ft modules , moored to a RO/RO ship,

TABLE 3.1
CARGO TYPES

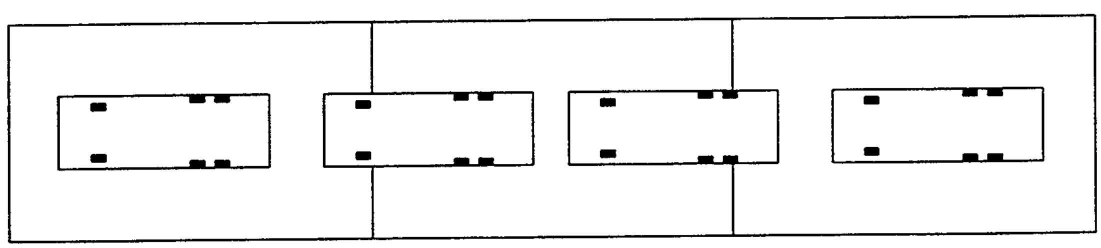
Cargo		Size	Weight	Wheel	Loading
Containerized					
ISO 20 foot Container		20ft x 8 ft	20 LT (max) 12.5 LT (nominal)		
ISO 40 foot Container		40ft x 8 ft	30 LT (max)		
Wheeled Vehicles					
Light Cargo Trucks M1008 M35A2C	nominal	24 ft x 8 ft	10.7 LT	9"x9"	4 k
Medium Cargo Trucks M927A1 M977	nominal	37 ft x 8.5 ft	26 LT	22"x11"	7.9 k
Heavy Cargo Trucks M911+M747 M916 + M871	nominal	58 ft x 8.5 ft	64 LT	10"x10"	8 k
Tracked Vehicles					
M1A1 Tank	nominal	26 ft x 12 ft	62.5 LT	25"x180"	70 k



14 x 20 FT. CONTAINERS 175 L.T. LOAD
(MAX. CONTAINER LOAD)



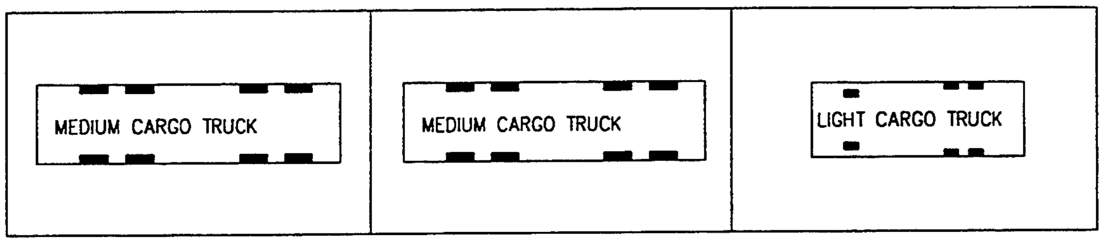
2 x 40 FT. CONTAINERS 60 L.T. LOAD



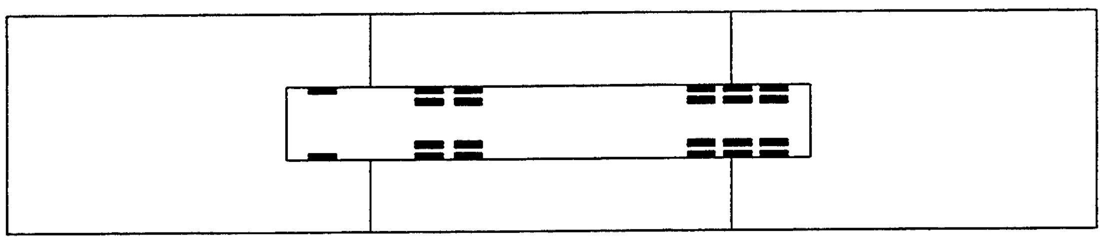
4 LIGHT CARGO TRUCKS 45 L.T. LOAD

FIGURE 3.2
TYPICAL CARGO LOADING ON 120 FT ASSEMBLY - SHT 1

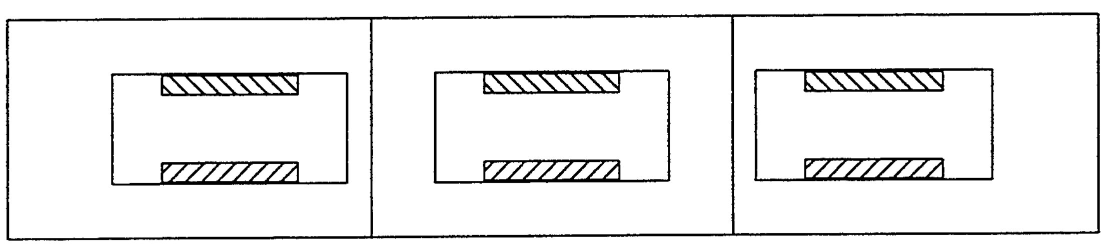
Kvaerner Masa Marine Inc.



MEDIUM CARGO AND LIGHT CARGO TRUCK
COMBINATION 64 L.T. LOAD

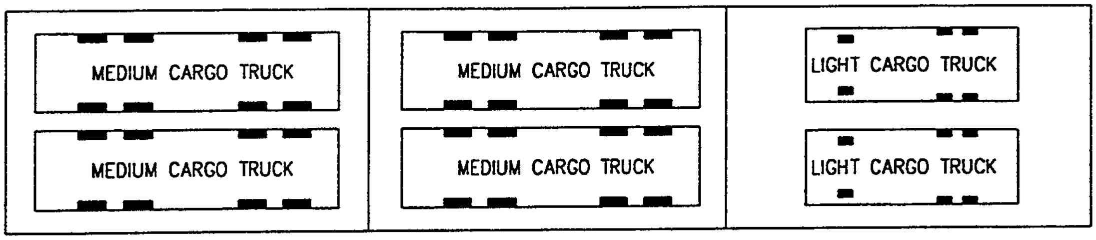


HEAVY CARGO TRACTOR TRAILER 64 L.T. LOAD

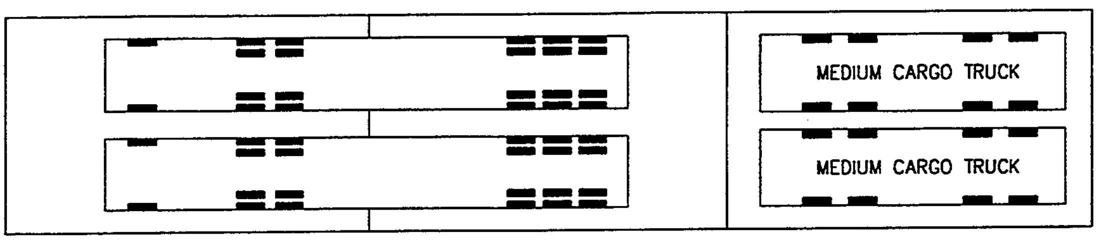


3 x M1A1 TANK 187.5 L.T. LOAD

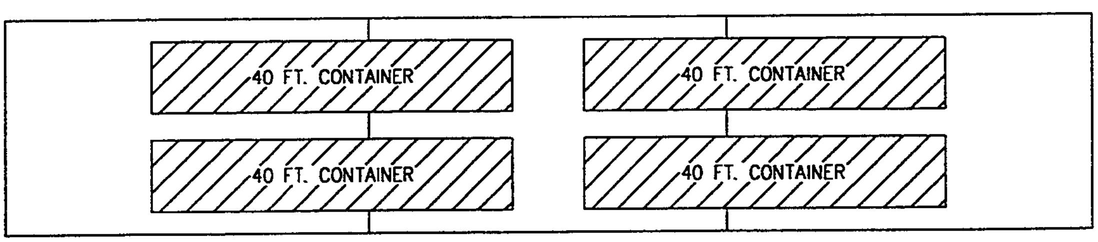
FIGURE 3.3
TYPICAL CARGO LOADING ON 120 FT ASSEMBLY - SHT 2



4 MEDIUM CARGO AND 2 LIGHT CARGO TRUCK
COMBINATION 128 L.T. LOAD



2 HEAVY CARGO TRACTOR TRAILER AND 2 MEDIUM CARGO TRUCK
COMBINATION 180 L.T. LOAD



4 x 40 FT. CONTAINERS 120 L.T. LOAD

FIGURE 3.4
TYPICAL CARGO LOADING ON 120 FT ASSEMBLY - SHT 3

It is assumed that the Elevated Causeway Facility (ELCAS) requirements will be met by a system other than the ACB.

The mission roles listed above will require the following interfaces:

- mooring between ACB and cargo ship, ELCAS, other lighters, and other ACB assemblies,
- anchoring,
- interface with the beach,
- interface with RO/RO ramp
  - existing NL system uses dunnage under ramp foot
  - it is assumed that the same will be applied to the ACB system operations
  - therefore, no specific requirement will be placed on the ACB module.

The interface requirements for the majority of these will be met by providing fittings on the module (see section 3.8) . The beach interface will require a specialized module with a beaching end folding section.

3.5 Hull Shape and Configuration

The hull shape and general configuration of the modules can be influenced or have dependence on several aspects of the systems operations. The general shape and overall basic dimensions for the modules and assembled barges have been defined as part of the original ACB concept under development. The concept and resulting basic configuration for the modules is based on the following premises:

- compatibility with standard ISO container modularity,
- method of transport in a manner similar to Navy SEASHEDS aboard T-ACS and ISO container ships,
- increased freeboard to ensure Sea State 3 operability,
- consistency with the basic requirements of the existing NL system.

From these premises the following choices of parameters were made and provided as baselines for the ACB development:

- 40 foot module length limit to suit 40 foot ISO container modularity,
- 25 foot maximum beam to suit SEASHED type transport scenario. This was subsequently revised to a 24 foot maximum beam to ensure compatibility with transport on the container grid of flat deck ships so equipped,
- 8 foot depth to provide increased freeboard and to suit ISO modularity,
- assembled barges of 120 foot length (3x40' modules) to be approximately consistent with the size of existing system assembled pontoons.

The resulting basic system consists of 24 x 40 x 8 foot modules to be rigidly connected in groups of three to form 120 x 24 x 8 foot barges which are then flexibly connected to form lighters, causeways, and platforms.

3.5.1 Module Identically Requirement

In principal the provision of identical modules could add to the versatility of the system. Also the general concept described above does not necessarily indicate a need for non-identical modules. However, the general philosophy of how the modules are to be interconnected, i.e. a rigid connection between 40 foot modules within a barge and a flexible connection between 120 foot barges, imposes some requirements on the module end shapes. The rigid connection between modules implies an advantage in a full depth square end shape to better transmit bending forces. The flexible connection between barges implies a raked end shape to ensure full freedom of motion for the articulation. Based on this, the modules will not be identical.

3.5.2 Resistance Dependence

Reference information for the lighterage operations indicates that the normal speed of operation in a powered mode (as a lighter barge or causeway ferry) is 6 knots. As well there is a potential need to increase this to 8 knots. Based on a review of barge form resistance data sheets [6], the following points about resistance characteristics of ACB barge forms can be stated:

- 6 knots for a 120 foot barge relates to a Froude number (V/sqrt(g*L)) of 0.16;
- at this Froude number, in general, the resistance curve gradient is shallow;
- the form drag or residuary resistance coefficient gradient is nearly flat;
- between hullform variations that include more or less of a transition at the waterline (bow form) and more or less shape to the hull section, the magnitude of the residuary resistance coefficient changes little;
- the presence of a raked bow and stern can significantly reduce the overall resistance;
- variations within the smoothness of the transition within the raked bow and stern can effect the resistance values.

The results indicate that there is little relative resistance dependence of the module hullform. The exception is that a raked profile should be provided bow and stern. Also should resistance characteristics become more significant, such as if an increased operational speed is to be considered, then a modification to the bow and stern profiles, through providing a smoother transition and eliminating the knuckle, should be examined.

3.5.3 Stability Dependence

Intact stability is a measure of the resistance of the hullform to capsize under operational loading conditions with the hull in an intact (not flooded) condition. Intact stability is a

function of the shape and size of the waterplane, the buoyancy distribution, and the location of the center of gravity of the hull and load. The intact stability characteristics can therefore depend on the hull form.

Barge forms, with their large waterplanes relative to their draft, have inherently large initial stability characteristics but sometimes with limited range. Also, deck barges, which the ACB can be considered, can sometimes experience large increases in the vertical position of the overall center of gravity as a result of large sized cargo loads. On this basis loading conditions can be limited by the need to maintain adequate stability.

No specific criteria or limitations on stability characteristics have been identified. As a measure of the relative characteristics and therefore the relative safety of the system the ACB stability will be compared against the standards contained in CFR 46 174 [7] for deck cargo barges. This standard requires that the barge have a minimum amount of righting energy stated in terms of an area under the righting arm curve.

Damage stability is a measure of the resistance of the hullform to capsize in a flooded condition, i.e. damage causing flooding of one or more of the hull watertight compartments. Based on the reference information, the likelihood of flooding type damage occurring during lighterage operations is high. Therefore, the hullform will need to be compartmentalized to the extent necessary to maintain adequate stability after damage.

Criteria for damage stability are normally related to: the extent of damage that needs to be considered, limitations on the equilibrium heel angle after damage, avoidance of deck edge immersion, and maintenance of positive stability and stability range. For the ACB modules, with a high likelihood of damage, particularly to the ends and the sides, it is concluded that damage occurring at a watertight compartment boundary could cause flooding of two adjacent compartments. The ACB should be designed based on withstanding the flooding of two adjacent compartments with limited transverse extent of damage.

No criteria or limitations for damage stability standard are specified. Based on typical damage criteria the following criteria will be used to define the relative damage stability characteristics for the ACB:

- equilibrium heel angle after damage limited to 15 degrees based on maintaining security of the cargo;
- no deck edge immersion;
- positive range of stability of at least 15 degrees.

Both intact and damage stability are to be analyzed for a single 120 x 24 foot barge, since this will be the worst case.

3.5.4 Motions Characteristics

The motions (seakeeping) characteristics of the ACB modules and assembled barges are of critical importance to the operability of the system particularly in higher sea states. The hull form and changes to it can have significant impact on these characteristics.

No specific motion limitations have been defined other than that overall motions of the modules and barges should be minimized. The ACB design, therefore, will need to be developed from a standpoint of allowing incorporation of features that may reduce motions wherever possible.

3.5.5 Hydrostatics and Displacement

An underlying premise of the concept is to provide increased freeboard to allow operations in higher sea states. It is assumed that an acceptable minimum freeboard for the ACB system would be in the range of 3 feet. This is based on the assumption that the freeboard of the existing NL lighters, which is approximately 3 feet, provides an acceptable height above the waterlevel to handle larger waves. Using the 8 foot depth guideline for the ACB system modules, 3 feet freeboard relates to five feet draft. If it is assumed that the maximum practical load that a 120 barge unit will be required to carry is 200 LT, and that each of the modules weighs in at the maximum of 30 LT, then the total displacement for the barge will be in the order of 290 LT. The minimum block coefficient allowable to provide a 3 foot minimum freeboard (5 foot draft) is then:

$$C_{Bmin} = \frac{\text{volume}}{L\,B\,T} = \frac{(35)(290)}{(120)(24)(5)} = 0.70$$

A block coefficient of less than this will not allow 3 feet freeboard at maximum load. This limit can be used in evaluation of potential hullforms. It should be noted that 3 feet freeboard is only used as a guide to evaluate changes to the hullform and is not based on an analysis of any criteria relating to water on deck or other seakeeping characteristic.

3.5.6 Connection/Assembly System Dependence

Based on the general information about the probable form and operation of the rigid and flexible connection systems, there does not appear to be any aspects of the hullform that would effect, either enhance or degrade, the connection/assembly processes. The qualification to this statement is that for the implied hull form end shapes given in Section 3.5.1, i.e. full depth square ends for the rigid connection and raked ends for the flexible connections.

The flexible connection system will also require a minimum depth of vertical structure at the end of the end module. From the descriptions of this system in reference [8], it is assumed that 2 feet will be sufficient.

3.6 Structure

3.6.1 Structural Arrangement

From the standpoint of the structural arrangement, the modules will be designed based on typical barge construction practices and design methods. The arrangement could consist of stiffened panels supported by a frame system, corrugated panels supported by a frame system, or a combination of these. The choice of the system to use and the arrangement will be based on the relative weight advantage compared against any additional complexity in construction. Typical barge construction arrangements, consisting of a system of watertight bulkheads, heavy frames supporting beams and stiffeners which in-turn support the deck and shell, is designed for application on structures where the primary support is provided by uniform hydrostatic pressure. Such a design methodology will provide the most efficient structure possible and result in modules that have more than adequate strength and stiffness.

3.6.2 Design Criteria

The ACB system will in effect operate as deck cargo barges or barge trains. No specific regulatory requirements have been stated as being required. As a basis for development of scantlings the following methodology will be used:

- Use ABS Rules for river service [9] and ABS Rules for Steel Barges [10] to define initial scantlings including specific wheel loads for deck plate and supporting structure. These are empirically based and derived from what has been determined to be adequate structure for existing in-service vessels under a wide range of loading conditions,
- Check these scantlings and define stress levels under specific loading defined for ACB operations and including both local and global effects,
- Include the effects of dynamic load factors, sufficient to allow for SS3 conditions.

3.6.3 Loading

From the reviewed reference documentation the following load types and magnitudes need to be considered:

- Cargo Loads,

  RTCH, 75,000 pound wheel load,
  Cargo Trucks, up to 16,000 wheel load,
  M1A1 Tank, 140,000 total load;

- Hydrostatic Loads;
- Hydrodynamic Loads, if slamming is determined to be of concern;
- Lifting Loads;

- Stowage Loads for Modules onboard a transport ship.

The governing load for the deck plate will be wheeled cargo tire patch loads. These are the largest local load identified. For design, the plate thickness and stiffener spacing will be determined from the "Heavy Cargo Truck" wheel load and patch, as given in the Sealift COR [2], using the ABS Rules wheel load design approach assuming the application of a dynamic factor and considering the deck as a "strength" deck. The resulting panel will then be checked against the higher RTCH wheel load to estimate the amount of permanent set to be expected. This approach is felt to be appropriate since the RTCH is only an occasional load and since it is assumed that a small amount of permanent set is acceptable.

Deck supporting structure will be designed to carry the RTCH load using direct calculation methods and an allowable bending stress of 67% of yield. Other structure designed using direct calculation methods will use 67% of yield as an allowable stress level.

Other structural members will be sized to the scantling requirements of ABS Rules based on 120 foot barge dimensions. Areas of the structure will then be check for stress levels under specific loading conditions and configurations including of stability of the structure against buckling collapse.

The hull girder strength will be reviewed relative to moments derived in previous hydrodynamic analyses as well as against static loading conditions in still water and on a wave. Scantlings will be revised to suit global stress limits, if required.

3.6.4 Materials

The requirements for potential materials to be used on the ACB structure are:

- durability,
- maintainability,
- availability.

Materials to be considered include:

- steel

- Mild (ordinary strength) steel	marine grade	34 ksi yield
- High strength steel	marine grade H36	51 ksi yield
- HY80/HY100 steels		80/100 ksi yield

The use of high strength steel is relatively common in ship building in specialized applications. Availability should not be a problem and workmanship requirements and skill levels are not stringent. High strength steel is to be considered for the ACB structure in areas of high stresses if a weight advantage can be realized.

The higher strength steels, HY80 and HY100 (MIL-S-16216), are used in marine applications primarily in surface combatants in areas of the hull where very high stresses may occur. These steels, in addition to providing high yield characteristics, provide superior fracture toughness. The use of these steels for the ACB would impose a relatively high cost penalty since they are not as common and require specialized fabrication skills. These steels may provide a weight advantage due to their high strength. However their use should only be considered together with their negative impact on the eventual unit cost.

- aluminum
  - availability is high
  - requires some degree of specialized skill and knowledge to work with
  - not as durable as steel
  - susceptible to fatigue

  The use of aluminum should not be considered.

- composites

  - composites in marine use have so far been limited to GRP/FPR laminate hulls, sandwich panels for deckhouses (references [11] and [12]), and joiner work,
  - use in heavy load bearing applications is not proven.

  It is concluded that the use of composites is not warranted.

- other materials

  Plastic materials could find use in self contained buoyancy compartments similar to modular floating dock technology. Wood could find use in load spreading, sacrificial deck sheathing applications. The use of other material in these types of non load bearing applications should not be precluded.

3.7 Propulsion

Propulsion for the ACB will be with an ISO powered module using 360 degree rotatable waterjets (see reference [13]). The development of this module is outside the scope of the ACB module research effort.

3.8 Hull and Deck Outfit

Interface requirements for the ACB have been identified in previous sections. Those interfaces that will impact on the level of hull and deck outfit that is required to be provided include:

- Transportation Configuration

  - interface to container ship/T-ACS container cell guides,
  - interface with typical container deck fittings on a RO/RO or other flat deck ships for transportation,
  - interface for securing ACB modules to deck of ship not equipped with container deck fittings,

- Deployment

  - interface with standard ISO 40 foot container spreader for lifting on T-ACS and container ships,
  - interface for lifting on ships not equipped with container spreaders,

- Cargo Operations

  - interfaces for mooring the ACB barges or lighters to: cargo ship, ELCAS facility, Warping Tug, other lighter,
  - interfaces for anchoring operations when used as a causeway,
  - cargo interfaces (tie downs)

Cargo operations and module stacking configuration will require that any fittings provided to meet these interfaces be low profile flush type. Based on these requirements, the following type of fittings will be provided:

- ISO Container Fittings

  - 4 - ISO container corner fittings to be provided on the top of each module, nominally 4 feet off centerline to port and starboard, between the end notches for the container cell guides,
  - ISO container fittings to be provided on the bottom of each module in the same general position as the top fittings. Two fittings for the end modules, 4 for the central modules,
  - fittings to be arranged to match the tolerances given in ISO standards [14].

- Heavy 'D' Ring Lifting Lugs

  - 4 recessed type heavy 'D'ring type lifting lugs are to be provided symmetrically placed on the top of each module in way of significant supporting structure (bulkhead or girder), to be used in connecting lifting bridles and slings for ships not equipped with container spreaders. Lug to be sized to carry the maximum light weight of the module with lifting dynamics considered.
  - alternately detachable padeyes can be provided that can be bolted to the deck of the modules when required for lifting operations.

- Securing Fittings

  - recessed securing fittings are to be provided along the sides and possibly the ends of the modules for use in lashing to the decks of ships not equipped with container deck fittings or to provide additional support when stacked,
  - alternately detachable securing padeyes can be provided.

- Mooring Fittings

  - up to five mooring fittings are to be provided along the port and starboard sides of a 120 foot assemble barge. One arrangement could be to provide one each port and starboard on the end modules and three each port and starboard on the central module.
  - fittings could be either detachable bits/cleats or recessed bits/cleats.

- Anchoring Fittings

  - up to three of the provided mooring fittings should be designed to be used in anchoring operations as well.

- Cargo Tie downs

  - a tie down grid should be provided that will allow stowage of cargoes basically in any orientation or location,
  - an example grid could consist of two rows of cloverleaf type fittings along each edge of the modules, spaced 6 feet apart longitudinally and 3 feet transversely, with a row of 'D' rings between the cloverleafs.

Other fittings that will be required relate to non-operational or transport requirements including:

- Access

  For inspection and maintenance purposes, each watertight compartment in the modules will require to be fitted with bolted access panels or flush-type manholes. These should be located near to the boundary of the compartment adjacent to a watertight bulkhead and in line with vertical ladders or ladder rungs.

- Machinery Connections

  There may be a requirement for connection fittings to be provided for mechanical systems. The requirements for systems are not defined but may include water ballast,

fuel storage etc. Any such fittings should be provided in recessed pockets in the deck with removable covers.

- Connections System Related Fittings

  The connection systems (rigid and flexible) are currently under development and details are not available. Reservations in space and weight should be incorporated into the ACB design. Types of fittings that may be required include:

  - through deck fitting for passing marriage lines,
  - mounting plates for portable winches or bits,
  - access panels for installation and maintenance of connection system units,
  - hydraulic fittings.

4.0 DESIGN DEVELOPMENT

4.1 Hydrodynamics Comparison of Hullform Variations

4.1.1 General

As discussed in Section 2, the Technology Review identified several potential measures that would tend to reduce the module motions. The measures identified included a variation to the hullform in a catamaran form, and the use of fixed passive damping systems. The objective of this part of the research effort was to quantify the effects on the overall module motions of a catamaran form, as well as selected passive damping system that included: attached perforated plates, an integral open truss, and a free surface type stabilization tank. The analyses of these options were developed using numerical motion prediction software for the hull form variations and empirical information to quantify the effects of the damping systems. Figure 4.1 shows the basic geometry of the hullforms and other options analyzed.

4.1.2 Methodology

The basis of the hydrodynamic calculations is a 3D radiation/diffraction program called AQWA-LINE. AQWA-LINE is a bureau standard code capable of modeling any stationary floating hull form subjected to wave actions using potential flow theory. The code provides the complete hydrodynamic properties such as added mass, wave (radiation) damping, excitations, hydrostatic stiffness as well as Response Amplitude Operators (RAO's) for six degree-of-freedom motions of the vessel. The excitation functions include Froude-Krylov forces, diffraction forces as well as second-order steady wave drift forces. In the present application, all of the above parameters are calculated for a range of wave frequencies and four relative wave directions.

The two hullforms modeled in AQWA-Line are based on a rigid barge hull form in the monohull as well as in the catamaran hull configurations. All models developed were for the hullforms in the unloaded light condition. Three lengths of each hull form were modeled, 40, 80, and 120 feet, representing one, two, and three modules rigidly connected end-to-end, with displacements of 30, 60, and 90 LT, respectively. One additional case of two 120 foot hulls of the monohull form rigidly connected side-to-side was also analyzed. The hull surface is described by a finite element mesh with a pulsating "source" located on each element. The hull surfaces were modeled using approximately 600 diffracting and non-diffracting quadrilateral plate elements. The raked ends of the 80 and 120 foot configurations were not modeled as it was felt that these would have only minor effects on pitch and heave motions. With this simplification, the two hulls types both have longitudinal as well as transverse symmetries, which reduced the modeling efforts. Figures 4.2 and 4.3 depict typical hull geometry models for the two types of hull forms. The accuracy of the models were verified by examining the geometry and separate hand calculations of the hydrostatic properties.

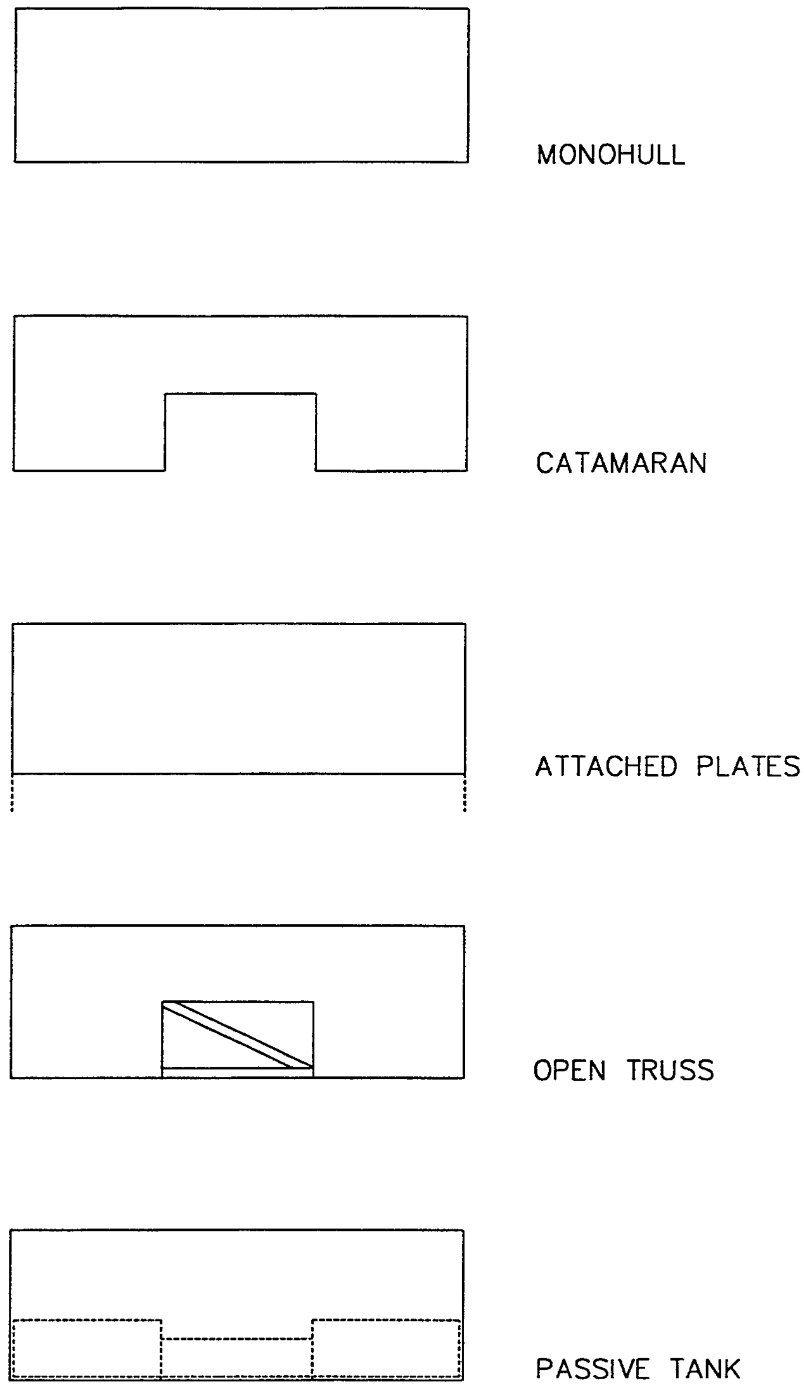


FIGURE 4.1
MODULE VARIATIONS ANALYZED

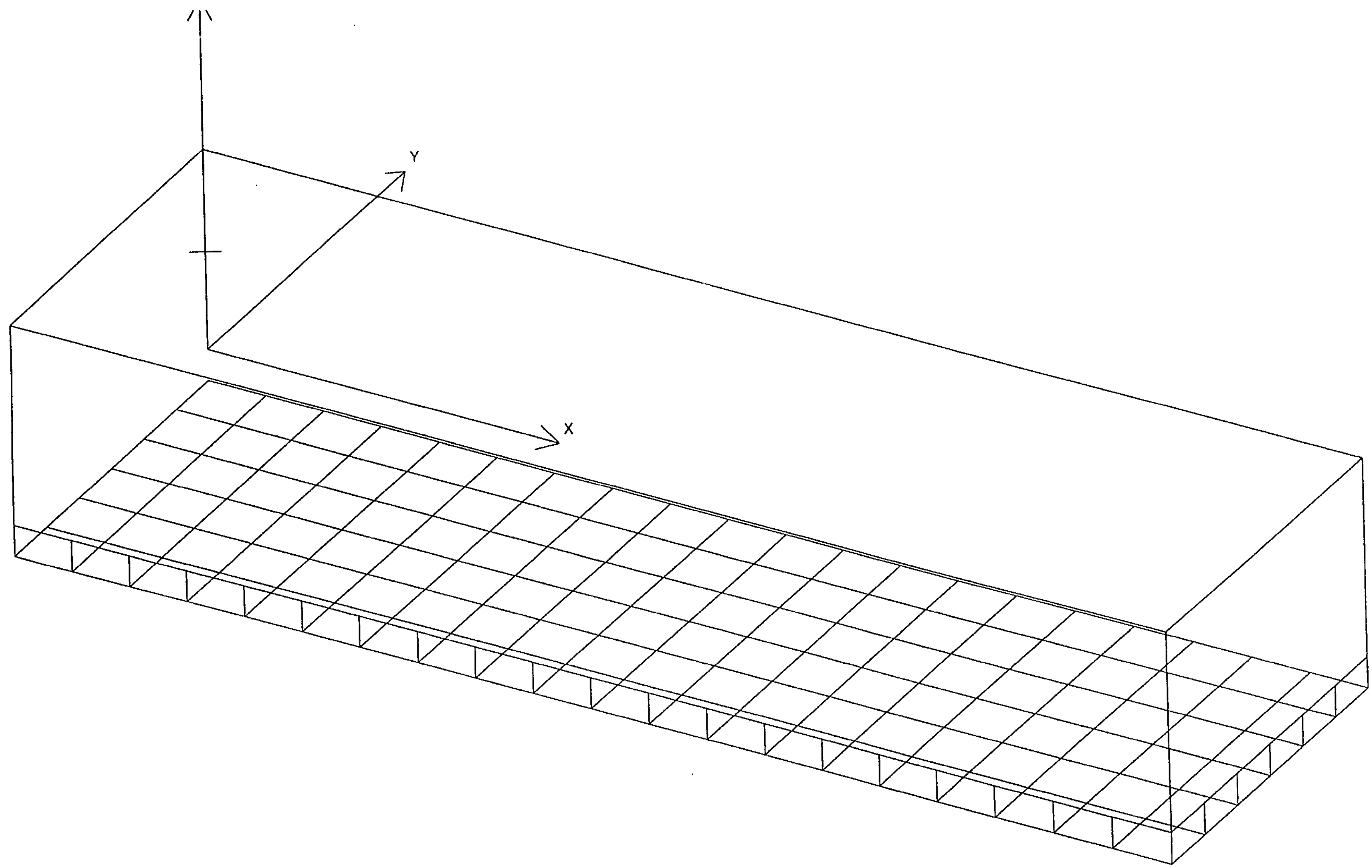


FIGURE 4.2
TYPICAL MONOHULL GEOMETRY MODEL

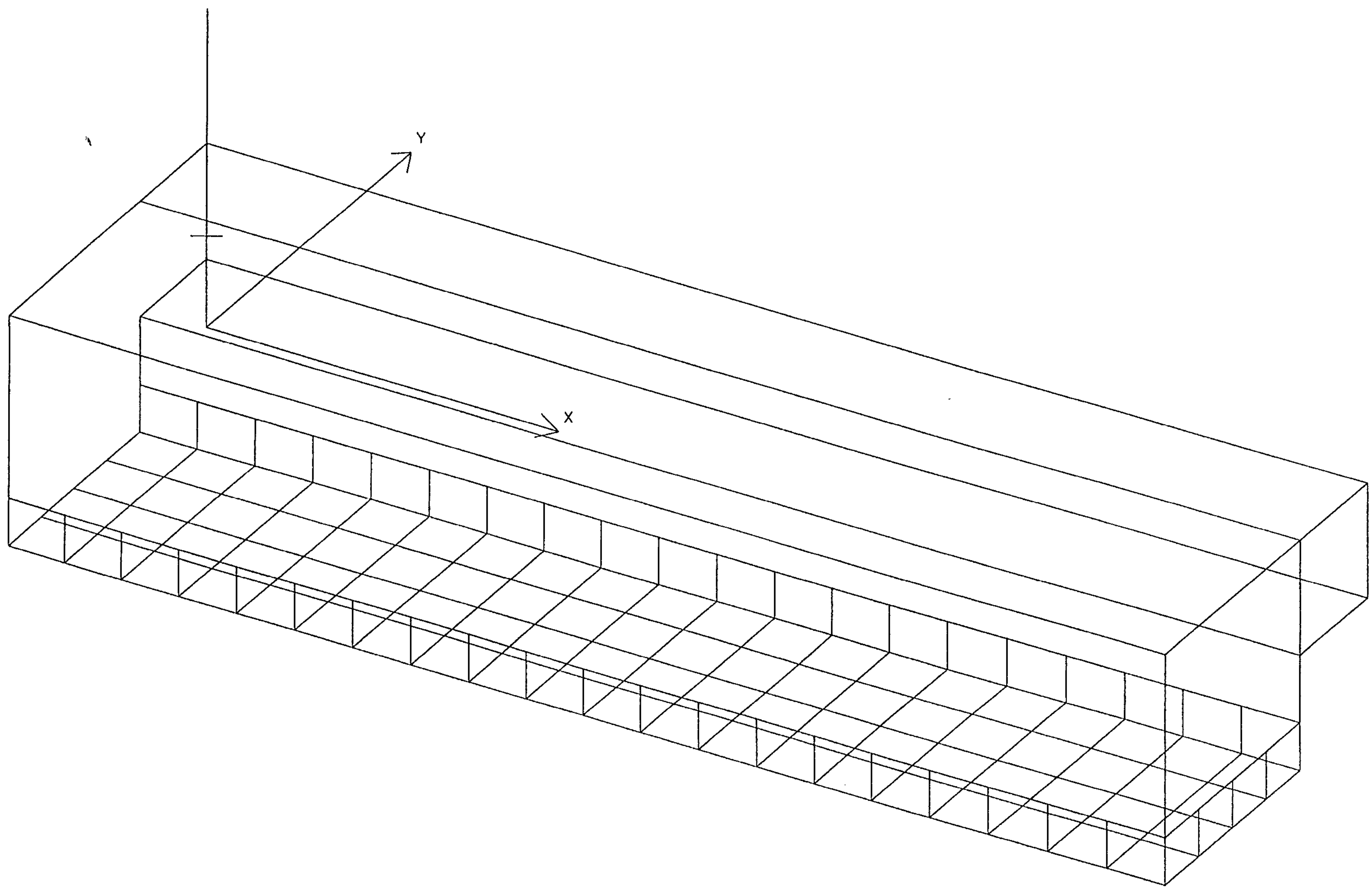


FIGURE 4.3
TYPICAL CATAMARAN GEOMETRY MODEL

Motions of the monohull and catamaran concepts have been computed in two sea states, one representing a nominal sea condition (SS 2.5) and the other an extreme condition (SS 5). The nominal SS 2.5 condition was chosen to facilitate comparisons and benchmarking of the results with previous numerical results (Garrison [15]). The relative motion effects between the hull form variations can be considered applicable to SS 3 conditions as well. The wave parameters used for these two conditions are as follows:

Sea State	Sig. Wave Height	Modal Period
2.5	3.0 ft	5 s
5	10.0 ft	9.1 s

The Bretschneider two-parameter spectral formulation for fully developed seas was used to represent the above sea states. It is assumed that the waves are unidirectional and longcrested, which is a conservative assumption for motion calculations. All calculations have been carried out for a water depth of 50 feet, although motion responses are not expected to be sensitive to the water depth.

The perforated plate arrangement designed for attenuating the wave-induced motions was modeled as appendages that modified the hydrodynamic added mass and damping especially in the roll and sway motions. The background for this approach is a research program at the National Research Council of Canada, Hydraulics Lab, relating to the use of perforated plates to add damping to floating bodies [16]. The attached plates were modeled with 40% perforations, the size of the individual holes not being relevant. The empirical data on the motions damping characteristics of these plates are not explicitly documented and observed oscillation decay tests were used to estimate the damping factor for an arrangement in which two plates were attached to the module/s. This was primarily aimed at providing additional damping in the roll mode so that roll motions can be significantly reduced. Damping due to the appendages were modeled as non-linear functions of velocity, equivalent linearizations of which were used to determine the modified motion RAO's.

An open truss structure on the catamaran hullform was modeled as consisting of small diameter members for which the forces can be defined using Morison's formula (see reference [17]) for cylinders which comprise drag and inertia terms with constant coefficients. It is assumed that the tubular elements are not effected by the diffracted and radiated flow fields so that AQWA-LINE modeling is not required. These tubular members contribute locally to damping primarily in heave and pitch, the net effect obtained by adding the forces on each element. The damping is, once again, nonlinear which is modeled by equivalent linearization techniques. An inertia coefficient of 1.0 and a drag coefficient of 1.2 have been used in the analysis.

A simple rectangular free surface tank was investigated to demonstrate the reduction in roll motion that can be achieved using an open passive tank. The 40 foot monohull form was

modeled to include additional displacement due to the water in the tank. The magnitude and phase of the roll stabilizing moment due to the tank was determined using published semi-empirical data [18]. This is followed by re-calculation of the roll RAO after incorporating the stabilizing moment into the uncoupled roll equation of motion. The modified RAO is used to calculate the response in irregular seas. The analysis takes into account the reduction of GM due to the liquid free surface in the tank, which is not considered serious as the barge is relatively "stiff" in roll. The calculations have been carried out for one height of water level in the tank only. The water in the tank for the configuration analyzed amounted to about 20% of the displacement.

4.1.3 Results

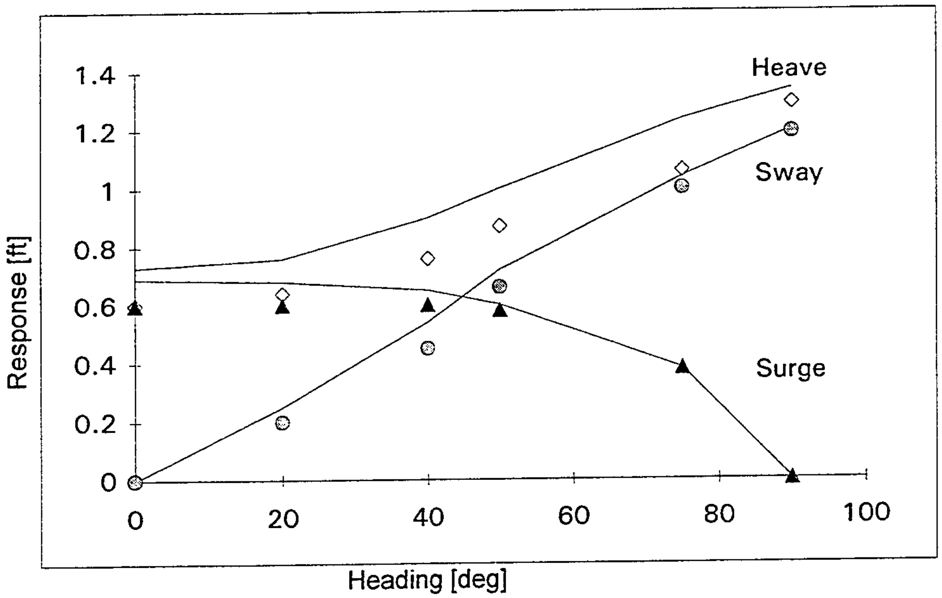
As a bench mark for the calculations, a 2 module barge hull form was modeled using the hull parameters taken from Garrisons report [15]. Motion RAO's calculated for six relative wave directions were subjected to the irregular wave spectra defined above and the single significant response amplitudes were computed. The results were plotted against the wave direction as in [15] and are shown in Figures 4.4 a and b. The comparison shows that, in general, the motions compare well. It must be noted that some difference is expected as the spectral formulations are not the same, but the wave height and modal period are the same so that the distribution of the wave energy over the range of frequencies is the same.

Tables 4.1 through 4.6 summarize the results of the motion comparisons for the options and configurations analyzed in both nominal and extreme sea states. The same data is presented in graphical form in Appendix B. The numbers in the tables represent single significant amplitudes of all six modes of motions for four relative wave directions. Comparisons between monohull and catamaran forms can easily be made between the left and right sides of the tables. It can be seen that there is very little difference in motions between the hull forms for all three barge lengths in both sea states.

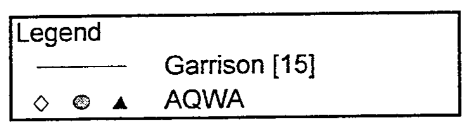
Typical variation of motions with wave height can be seen by examining the tables of motions for the single 40 ft module, Tables 4.1 and 4.2. The increase in amplitude of motions is less a linear increase with wave height. Surge, sway, and heave modes increase in amplitude by as much as 100%, independent of wave direction, between the two wave heights. Pitch and roll modes increase by 50% and 60% in head and beam seas respectively. Similar variations are observed with all three hull lengths.

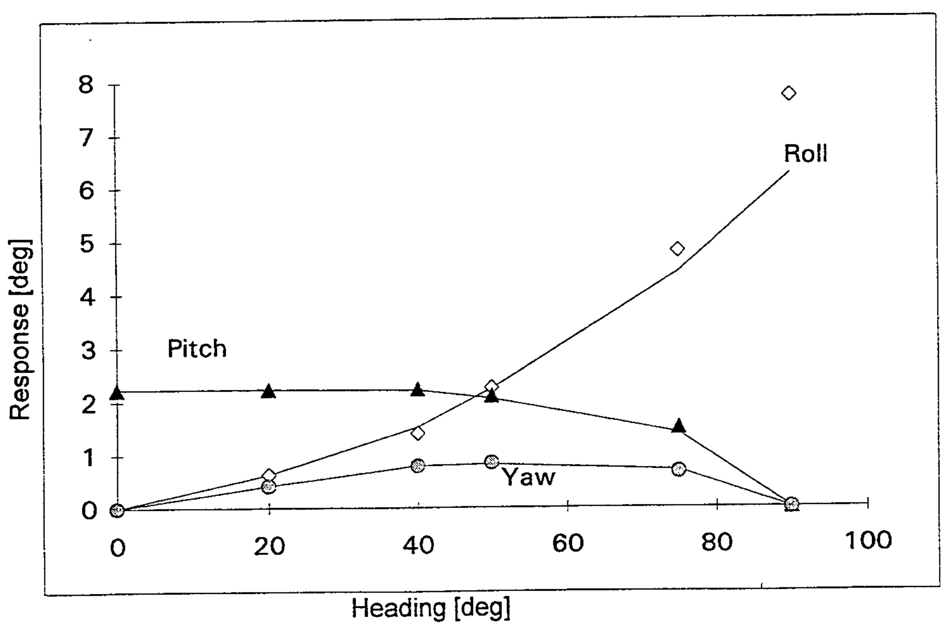
Comparisons of motions between the 40 and 80 ft hulls show that surge and sway motions decrease by 10% to 30% while heave motions decrease by 40% in head seas and only 2% in beam seas. A 50% reduction in pitch response is indicated while no significant roll reduction is seen in beam seas. The latter result is expected as the 80 ft hull and the 40 ft hull have the same beam and draft.

FIGURE 4.4
BENCHMARK WITH GARRISON'S RESULTS



a) Heave, Sway, and Surge





b) Roll, Pitch, and Yaw

TABLE 4.1
MOTION PREDICTION OF 40' MODULES

SEA STATE 2.5
Significant Wave Height = 3 ft
Modal Period = 5 s

	MONOHULL				TWIN HULL			
Wave Heading	0°	30°	60°	90°	0°	30°	60°	90°
Motion								
Surge, ft	0.34	0.20	0.09	0.00	0.34	0.21	0.09	0.00
Sway, ft	0.00	0.15	0.41	0.82	0.00	0.16	0.42	0.81
Heave, ft	1.02	1.07	1.20	1.27	1.03	1.08	1.17	1.24
Pitch, deg	4.66	4.25	2.69	0.00	4.98	4.41	2.70	0.00
Roll, deg	0.00	2.05	5.13	7.53	0.00	2.02	5.10	7.48
Yaw, deg	0.00	0.91	1.80	0.00	0.00	0.90	1.70	0.00

ATTACHED PERFORATED PLATE WITH 40% HOLES

	MONOHULL			
Wave Heading	0°	30°	60°	90°
Roll Motion, deg				
2 ft Plates	0.00	1.61	2.73	3.19
4 ft Plates	0.00	1.56	2.61	3.05

WITH 6" DIA. TRUSS - STRUCTURE BETWEEN HULLS

		TWIN HULL			
Wave Heading		0°	30°	60°	90°
Motion					
Heave, ft		0.98	1.00	1.15	1.20
Pitch, deg		4.51	4.31	2.53	0.00

WITH PASSIVE ROLL TANK

	MONOHULL
Wave Heading	90°
Motion	
Roll, deg	5.41

TABLE 4.2
MOTION PREDICTION OF 40' MODULES

SEA STATE 5
Significant Wave Height = 10.0 ft
Modal Period = 9.1 s

	MONOHULL				TWIN HULL			
Wave Heading	0°	30°	60°	90°	0°	30°	60°	90°
Motion								
Surge, ft	0.73	0.42	0.18	0.00	0.71	0.40	0.17	0.00
Sway, ft	0.00	0.32	0.86	1.59	0.00	0.32	0.84	0.00
Heave, ft	2.19	2.25	2.40	2.47	2.21	2.26	2.37	2.43
Pitch, deg	7.10	6.33	3.87	0.00	7.40	6.51	3.88	0.00
Roll, deg	0.00	3.27	7.13	9.73	0.00	3.22	7.07	9.64
Yaw, deg	0.00	1.90	3.49	0.00	0.00	1.70	3.39	0.00

ATTACHED PERFORATED PLATE WITH 40% HOLES

	MONOHULL			
Wave Heading	0°	30°	60°	90°
Roll Motion, deg				
2 ft Plates	0.00	2.83	4.74	5.47
4 ft Plates	0.00	2.77	4.58	5.27

WITH 6" DIA. TRUSS - STRUCTURE BETWEEN HULLS

		TWIN HULL			
Wave Heading		0°	30°	60°	90°
Motion					
Heave, ft		2.18	2.20	2.24	2.34
Pitch, deg		6.90	6.11	3.62	0.00

TABLE 4.3
MOTION PREDICTION OF 80' MODULES

SEA STATE 2.5
Significant Wave Height = 3.0 ft
Modal Period = 5.0 s

	MONOHULL				TWIN HULL			
Wave Heading	0°	30°	60°	90°	0°	30°	60°	90°
Motion								
Surge, ft	0.30	0.18	0.07	0.00	0.29	0.18	0.08	0.00
Sway, ft	0.00	0.11	0.34	0.76	0.00	0.12	0.34	0.77
Heave, ft	0.57	0.67	1.00	1.30	0.57	0.67	0.99	1.26
Pitch, deg	2.18	2.23	1.99	0.00	2.25	2.30	1.92	0.00
Roll, deg	0.00	1.05	3.04	7.50	0.00	1.23	2.99	7.48
Yaw, deg	0.00	0.82	1.51	0.00	0.00	0.82	1.50	0.00

ATTACHED PERFORATED PLATE WITH 40% HOLES

	MONOHULL			
Wave Heading	0°	30°	60°	90°
Roll Motion, deg				
2 ft Plates	0.00	0.94	2.23	3.19
4 ft Plates	0.00	0.93	2.16	3.05

WITH 6" DIA. TRUSS - STRUCTURE BETWEEN HULLS

		TWIN HULL			
Wave Heading		0°	30°	60°	90°
Motion					
Heave, ft		0.50	0.65	0.95	1.11
Pitch, deg		2.20	2.27	1.84	0.00

TABLE 4.4
MOTION PREDICTION OF 80' MODULES

SEA STATE 5
Significant Wave Height = 10.0 ft
Modal Period = 9.1 s

	MONOHULL				TWIN HULL			
Wave Heading	0°	30°	60°	90°	0°	30°	60°	90°
Motion								
Surge, ft	1.71	0.94	0.28	0.00	1.70	0.92	0.26	0.00
Sway, ft	0.00	0.61	1.50	2.50	0.00	0.60	1.50	2.30
Heave, ft	3.30	3.50	3.97	4.30	3.30	3.51	3.95	4.24
Pitch, deg	6.20	5.70	3.96	0.00	6.26	5.78	3.91	0.00
Roll, deg	0.00	2.95	6.50	10.90	0.00	3.08	6.45	10.80
Yaw, deg	0.00	2.40	4.20	0.00	0.00	2.30	4.20	0.00

ATTACHED PERFORATED PLATE WITH 40% HOLES

	MONOHULL			
Wave Heading	0°	30°	60°	90°
Roll Motion, deg				
2 ft Plates	0.00	2.82	5.57	6.98
4 ft Plates	0.00	2.80	5.47	6.80

WITH 6" DIA. TRUSS - STRUCTURE BETWEEN HULLS

		TWIN HULL			
Wave Heading		0°	30°	60°	90°
Motion					
Heave, ft		2.95	3.12	3.78	4.00
Pitch, deg		5.80	5.52	3.87	0.00

TABLE 4.5
MOTION PREDICTION OF 120' MODULES

SEA STATE 2.5
Significant Wave Height = 3.0 ft
Modal Period = 5.0 s

	MONOHULL				TWIN HULL			
Wave Heading	0°	30°	60°	90°	0°	30°	60°	90°
Motion								
Surge, ft	0.28	0.15	0.04	0.00	0.24	0.13	0.06	0.00
Sway, ft	0.00	0.08	0.29	0.70	0.00	0.09	0.30	0.70
Heave, ft	0.30	0.39	0.77	1.24	0.29	0.38	0.76	1.25
Pitch, deg	1.10	1.24	1.44	0.00	1.12	1.26	1.43	0.00
Roll, deg	0.00	0.65	2.27	7.30	0.00	0.66	2.25	7.50
Yaw, deg	0.00	0.77	1.37	0.00	0.00	0.76	1.37	0.00

ATTACHED PERFORATED PLATE WITH 40% HOLES
MONOHULL

Wave Heading	0°	30°	60°	90°
Roll Motion, deg				
2 ft Plates	0.00	0.58	1.70	3.18
4 ft Plates	0.00	0.57	1.65	3.00

TWO 120 FOOT MODULES CONNECTED SIDE-TO-SIDE
MONOHULL

Wave Heading	0°	30°	60°	90°
Motion				
Surge, ft	0.28	0.19	0.13	0.00
Sway, ft	0.00	0.21	0.52	0.92
Heave, ft	0.32	0.39	0.61	0.96
Pitch, deg	1.13	1.20	0.88	0.00
Roll, deg	0.00	0.53	2.30	4.00
Yaw, deg	0.00	0.39	0.31	0.00

TABLE 4.6
MOTION PREDICTION OF 120' MODULES

SEA STATE 5
Significant Wave Height = 10.0 ft
Modal Period = 9.1 s

	MONOHULL				TWIN HULL			
Wave Heading	0°	30°	60°	90°	0°	30°	60°	90°
Motion								
Surge, ft	2.90	1.32	0.22	0.00	2.80	1.31	0.21	0.00
Sway, ft	0.00	0.84	1.57	2.67	0.00	0.83	1.55	2.59
Heave, ft	3.10	3.42	4.16	4.74	3.11	3.41	4.17	4.74
Pitch, deg	5.00	4.83	3.59	0.00	5.07	4.82	3.59	0.00
Roll, deg	0.00	2.37	5.79	11.00	0.00	2.36	5.78	11.00
Yaw, deg	0.00	5.70	8.10	0.00	0.00	5.30	7.90	0.00

ATTACHED PERFOREATED PLATE WITH 40% HOLES

	MONOHULL			
Wave Heading	0°	30°	60°	90°
Roll Motion, deg				
2 ft Plates	0.00	2.33	5.19	7.20
4 ft Plates	0.00	2.30	5.10	7.00

TWO 120 FOOT MODULES CONNECTED SIDE-TO-SIDE

	MONOHULL			
Wave Heading	0°	30°	60°	90°
Motion				
Surge, ft	1.21	1.07	0.64	0.00
Sway, ft	0.00	0.90	1.17	5.44
Heave, ft	1.81	3.36	3.75	4.44
Pitch, deg	5.02	4.69	2.70	0.00
Roll, deg	0.00	2.29	4.20	8.23
Yaw, deg	0.00	2.71	2.28	0.00

Comparisons of motions between a single 120 ft hull and two 120 ft hulls connected side-to-side (Tables 4.5 and 4.6) shows very little change for head sea directions. For the oblique sea directions and beam seas, however, the results show reductions between 20% and 40% for all modes of motion. The largest effects are for pitch in oblique conditions and for roll in beam sea conditions, as would be expected.

The perforated plate appendages were modeled on all three hull lengths for the monohull configuration. In the nominal SS 2.5, roll reductions obtained were in the range of 10% to 57%, while the extreme operating condition, corresponding reductions were 2% to 35%. From the above results, the effectiveness of these appendages to reduce roll motions was established.

The arrangement of open truss on the catamaran form is primarily aimed at providing additional damping in heave and pitch modes of motion. These effects produced heave motion reductions in the range of 2% to 5% and pitch motion reductions in the range of 3% to 10%.

The results of the analysis of the effects of a passive tank are included in Table 4.1. It can be seen that the roll reduction is approximately 30%. The passive tank is most effective at small roll angles and less effective for higher sea states which involve larger roll angles.

AQWA output documentation together with sample calculations are provided in Appendix B.

Implementing a passive tank system is likely to have detrimental effects on other aspects of the ACB design. The structure of the tank itself will add weight to the system. It is assumed that any motion reductions from the tank would only be useful in an unloaded condition during connections. Therefore, in order to avoid carrying around the tank water during the loaded operation of the ACB, some sort of deballasting system would be required which would add to the complexity and deployment times.

If any of the above options are to be implemented, all, with the exception of the passive roll tank, are likely to have some effect on the resistance characteristics of the ACB system. A set of analyses were undertaken to estimate the magnitude of these effects. Calculations are included in Appendix G.

For the monohull/catamaran comparison the resistance for each is estimated at the light unloaded draft condition, since this is the draft at which the twin-hull form is likely to show any resistance differences. Using the resistance methodology described in more detail in Section 4.3.4, it was estimated that the catamaran form at unloaded draft could be expected to have about 10% less resistance than the monohull form. However in a loaded condition the resistance is likely to be about the same as the monohull.

The estimate of the effects of open truss elements on resistance was determined by calculating the pressure drag on the truss elements as cylinders, using a drag coefficient of

1.2. The results indicated that the truss element could be expected to impose a severe resistance penalty, with the resistance of one set of truss elements amounting to approximately 30% of the total monohull resistance at full load. Considering all sets of truss elements would result in the truss drag dominating the total resistance.

The estimate of the drag of the attached perforated plates indicates that in a deployed position the plates could be expected to add about 10% resistance to the ACB form. It should be noted that implementation of this option would likely include a means of retracting the plates prior to operation as a ferry or barge, in which case the plates would impose no additional resistance.

Based on the results presented above it is clear that only the perforated plate option has any significant merit. The catamaran form itself showed insignificant reduction in motions as did the implementation of a truss system. As well any truss system was shown to likely have a serious detrimental effect on resistance. The passive roll tank could be designed to have positive effects however it would be likely add weight and significant complexity to the system. The perforated plate concept shows definite promise as a mean of reducing motions. The configuration analyzed was limited to an orientation effective in roll and sway only, due to the limitations of the empirical data available. It is likely that other orientations could be devised to help to reduce other modes of motion as well, with equal effect.

4.2 Conceptualization

The underlying philosophy of the ACB system concept provides a fairly rigid constraint on the module development from the standpoint of overall dimensions and end forms. Within the specified maximums, as discussed in Section 3.5, of 40 foot overall length, 24 foot overall breadth, and 8 foot depth, the obvious simplest configuration is a rectangular box form. This form has been taken as being a baseline.

A conceptualization process was undertaken with an objective of identifying any features or other module system concepts that may warrant a significant deviation form the baseline rectangular form. This conceptualization took the form of a brainstorming session during which alternatives for modular concepts were put forward.

Appendix C provides sketches and/or brief descriptions of the ideas presented during the session. The ideas presented cover a wide spectrum of topics not limited to specific module types within the ACB ISO modularity limitations. Most of these were felt to contain features that would necessarily put them well outside the scope of the current development. Three conceptual module forms, shown in Figures 4.5, 4.6, and 4.7 , were considered to have potential beneficial attributes and were evaluated further. These are:

- Concept 1 - flat cargo deck supported on three tubular steel "pipe" hull forms. This concept was inspired by commercial breakwater/dock applications that were identified

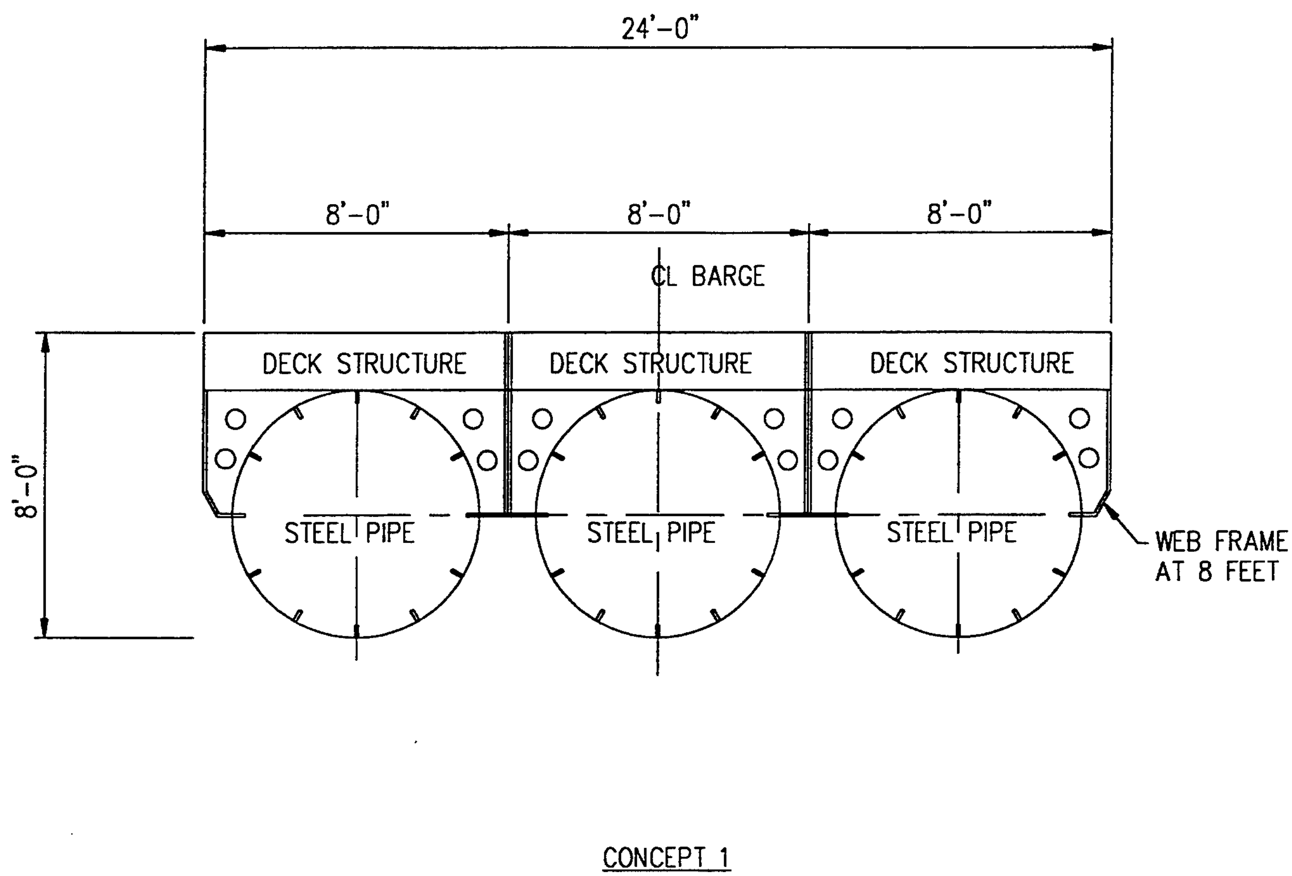


FIGURE 4.5
TUBULAR HULL MODULE CONCEPT

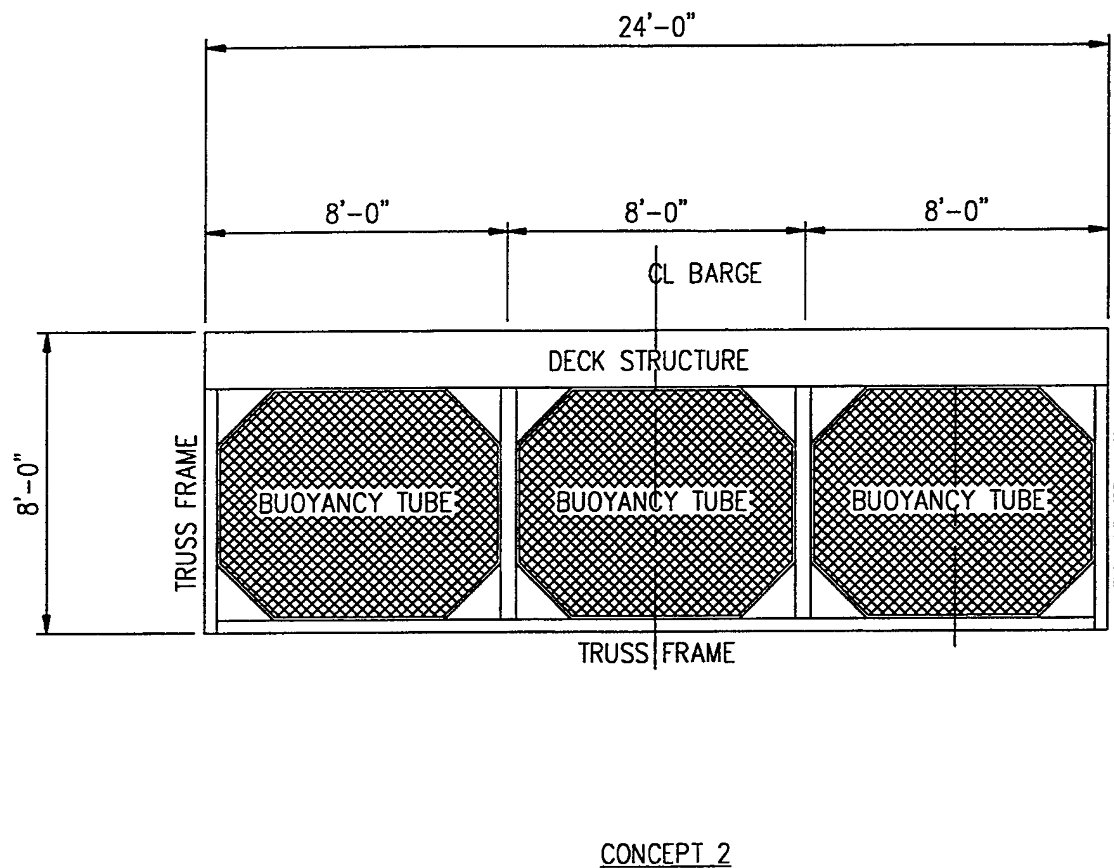


FIGURE 4.6
"COMMERCIAL DOCK" MODULE CONCEPT

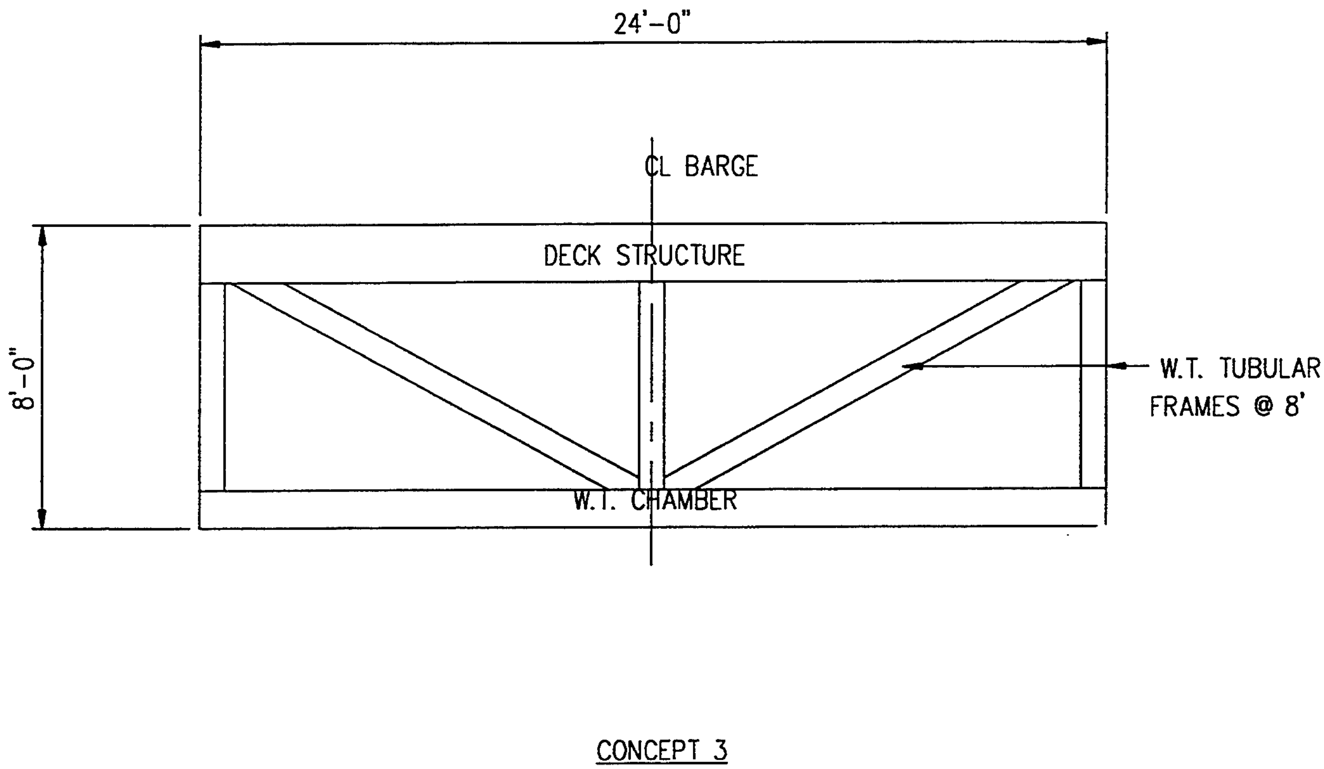


FIGURE 4.7
SEMI-SUBMERSIBLE BUOYANCY CONCEPT

in the Technology Review and was felt to potentially provide benefits principally in improved motions characteristics as well as ease in further breaking down the module into 8 foot pieces;

- Concept 2 - flat cargo deck supported on a truss frame and a set of independent plastic buoyancy compartments. This concept was inspired by commercial dock systems and was felt to offer potential advantages in weight and possibly reduced motions;
- Concept 3 - "semi-submersible" module consisting of a non-tight deck supported on watertight tubular struts and a watertight chamber. This concept was inspired by the well know superior motions characteristics of offshore semi-submersible structures.

Evaluation of these concepts included identifying the load carrying capacity at a standard defined loaded freeboard of 3 feet, as well as potential advantages and disadvantages relative to the baseline module form. Brief descriptions of these evaluations follow.

Concept 1 was estimated to have about the same weight as the baseline configuration but with only about 65% of the displacement capacity (a block coefficient of 0.65). Therefore, fully loaded this concept would operate with less than 3 feet of freeboard. The concept was felt to have the potential for increased damping and therefore reduced motions with it's three tubular hulls. It was expected to exhibit low resistance at lightly loaded conditions but to have a severe resistance penalty once the transverse web plates become submerged at deeper drafts. The concept would be easy to breakdown into 8 foot breadth pieces and was felt to be less susceptible to damage in operation.

Concept 2 was estimated to have about half the weight of the baseline concept with about 80% of the displacement capacity (a block coefficient of 0.78). Therefore, the concept would have greater than 4 feet of freeboard in a fully loaded condition. This concept was also felt to have potential for reduced motions, reduced susceptibility to damage with a greatly reduced effect of that damage. It was also felt to provide means of breakdown into smaller sections. The concept was felt to have a resistance penalty at all drafts.

Concept 3 was estimated to have about 70% of the weight of the baseline module but only 30% of the displacement capacity. This means that this concept would not be able to carry the full load. It was felt that if an altered configuration could be developed where additional buoyancy could be provided for deeper loaded draft conditions, that the concept would provide significant advantages in terms of superior motions

Based on these evaluations, only Concept 2 has potential, mostly from a significant reduction in weight. The concept would represent a significant departure from the direction of the current development, and several aspects would require to be proved. This may warrant further study, but was not felt to provide cause for deviation from the baseline form.

The brainstorming session also identified several simple modifications to the baseline module that were perceived to hold potential advantages. These are:

- the use of corrugated panels for shell and bulkheads to replace the panel stiffeners typical of barge construction. This was proposed as a means of reducing the structural weight and to, in certain aspects simplify construction;
- the addition of flare or deadrise to the hullform as a potential means of reducing motions.

Evaluation of the corrugated panel concept from a weight standpoint is discussed in Section 4.3.2. Evaluation of the application of flare or deadrise is discussed in Section 4.3.5 on module motions.

4.3 Concept Design

4.3.1 Structure

General Methodology.

The structure for the modules is generally developed from the philosophy of typical barge configuration and construction practice considerations. This is a reasonable approach since the primary mission of the ACB system is consistent with deck cargo barge operations. The structural analysis is developed working from a general definition of scantlings and following a process that provides a review of the structure under more specific analysis relating to actual ACB operational loading conditions.

The initial scantlings for the module have been developed using ABS Rules [9] for vessels in service on rivers and intercoastal waterways. These rules are empirically based and in general provide conservative plate thicknesses and stiffener scantlings using statistically derived values based on main dimensions. For the purposes the ACB structural analysis a rigid barge of 120 foot x 24 foot x 8 foot dimensions was used. These rules provide plate thickness for bottom and side shells, transom, headlog, and bulkhead; as well as section modulus requirements for stiffeners and other supporting structure for shell and bulkheads. For the deck plate thickness, initial scantlings were developed using ABS Rules for Steel Barges [10] which allow for an application of a dynamic factor that accounts for sea conditions, typical of open ocean operations. For deck beams and girders, scantlings were developed using direct calculation methods using dynamic factors for applicable loads.

The initial scantlings for the module as developed above were then reviewed subject to specific loading conditions that relate to ACB cargoes and loading conditions. These included:

- review of the deck panels from a standpoint of allowable permanent set (plastic deformation resulting in panel dishing) under the RTCH wheel loads,

- strength and stability of the bulkheads under wheel loads,
- global loading and strength of a 120 foot unit on a wave,
- review of the bottom shell against hydrostatic loading,
- loads due to a stacked stowage arrangement and due to lifting.

Structural Arrangement.

The structural arrangement has been defined based on several factors including:
- typical barge construction arrangements,
- compatibility with ISO modularity considerations,
- watertight compartmentation for damage stability,
- global strength,
- structural weight.

ISO modularity considerations suggested that an 8 foot grid of major structure be considered. This allows for even spacing both in the longitudinal and transverse directions. In addition to the normal level of transverse subdivision, damage stability considerations (see Sections 3.5 and 4.3.3) require some longitudinal subdivision to limit the transverse extent of flooding after damage.

From a global strength standpoint the preference would be for a longitudinal framing system, i.e. longitudinally oriented deck beams and shell stiffeners, for a long shallow hull form such as a 120 foot unit.

Weight considerations indicate that a transverse framing system will likely be slightly heavier than a longitudinal framing system (see discussion which follows in Section 4.3.2).

Based on these considerations the proposed structural arrangement consists of :

- deck and bottom shell supported by longitudinally oriented beams and stiffeners,
- beams and stiffeners supported by major structure (transverse girders or transverse bulkheads) spaced at 8 feet,
- transverse girders supported by longitudinal bulkheads located 4 feet off center port and starboard.

This arrangement provides an even span distribution for the major structure and effectively provides substantial bulkhead structure in way of the heaviest loaded section of the deck, i.e. under rolling stock track and wheel loads. This structure also will serve to support lifting loads placed on the ISO container corner fittings and for stowage loads that may be imposed on the container cell recesses.

Materials.

The use of marine grade steels is assumed throughout. As a weight saving measure, high strength steel, with a nominal yield strength of 51 ksi, is used for the heavily load structure

of the deck. Ordinary strength steel, with a nominal yield strength of 34 ksi, is used for the remainder of the structure.

Deck Design Results.

The governing loads for the deck plate and supported structure are from the rolling stock wheel loads which amount to the highest local loads that the module structure is required to bear. In particular the wheel load for the RTCH, of 75,000 pounds, is the heaviest load and is used to size the deck beams and deck transverses.

The philosophy for design of the deck plate involved sizing the deck plate using ABS Steel Barge rules [10] with the load for the Heavy Cargo Truck (as defined in the Sealift COR [2]). This analysis would ensure that no yielding or plastic deformation occurs under this loading with an ABS defined dynamic factor applied. The deck plate would then be reviewed from the standpoint of estimating the amount of cumulative permanent set as a result of loading over time that the plate would develop under the higher RTCH wheel loading.

The ABS calculation indicated that under Heavy Cargo Truck wheel loads, 1/4" thick deck plate on a 12" beam spacing would be required. This assumes the use of high strength steel as mentioned above. Estimations of permanent set were developed using design curves given in Hughes [19]. These curves provide a method for estimation of permanent set developed in a plate panel over prolonged application of a wheel load at any orientation to the deck panel. In any application of this method the most that can be derived are bounds on the level of permanent set to be expected.

This approach, using 1/4" deck plate under the RTCH loading, indicated that the total cumulative permanent set would be much less than 1/8". Based on this result it was decided to investigate the level of permanent set if a 24" beam spacing were used. The results of the analysis indicated that for 1/4" high strength steel the cumulative permanent set would be much less than 3/16" under the Heavy Cargo Truck wheel loads and between 3/16" and 3/8" inch under the RTCH loading. Given the nature of the analysis these levels were felt to be reasonable for the following reasons:

- the analysis itself is conservative being based on a cumulative total over time with the load in any orientation. The most likely orientation is longitudinally which is the least severe for loading,
- the wheel patch size as derived from the Sealift COR is conservative,
- these levels of permanent set will cause no degradation of structural performance.

It should be noted that the change in beam spacing from 12 inches to 24 inches results in a significant weight saving.

As a point of comparison, the present NL system modules have 3/16" plate on an approximate 21" beam spacing. This results in a larger slenderness ratio, panel width to thickness, than for 1/4" thickness on 24" spacing.

Deck beams and deck transverse girders are all designed to carry the RTCH load and are sized to keep stresses within the allowable level previously discussed.

Global Strength.

Global strength of the ACB lighter system has been analyzed using a classical naval architecture approach. Hull girder shear and bending moment estimations are made for specific loading conditions derived from the cargo types discussed in Section 3.4 with the hull in still water and wave conditions. For wave conditions the 120 foot hullform was balanced on a "L/20" wave. A "L/20" wave is a theoretical worst case wave that has a wave length the same as the length of the hull and a wave height of 1/20 th of the hull length, usually of a trochoidal profile. For 120 foot rigid unit this results in a wave 120 feet long crest to crest and 6 feet high crest to trough.

Loading conditions analyzed included:

- a single M1A1 tank in still water,
- 3 - M1A1 tanks even spaced along the 120 foot length in still water,
- 3 - M1A1 tanks closely spaced amidships in still water,
- 3 - M1A1 tanks closely spaced amidships on a sagging wave (trough amidships),
- 2 - M1A1 tanks at ends on a hogging wave (crest amidships).

The loading condition resulting in the largest moment was the 3- M1A1 tanks on a sagging wave. The load, shear and moment distributions are shown in Figure 4.8.

Primary stress (hull girder bending stress) is calculated by applying the maximum moment to the hull girder section modulus for the midship section or any other section of interest..

Dynamic Factors.

A dynamic factor of 1.5, to account for sea state, has been taken into account in analysis of the ACB structure. This factor is the same as use by ABS steel barge rules for design of decks. As a check of this, dynamic factors have been estimated using DOD Standard 1399 [20] which gives formula for vertical, transverse, and longitudinal accelerations as a function of sea conditions. These accelerations are shown in Figure 4.9 and range from 1.2 to 1.3 g. Therefore the use of 1.5 dynamic factor is reasonable.

Kvaerner Masa Marine Inc.

FIGURE 4.8
LOAD, SHEAR, AND MOMENT DISTRIBUTIONS
3 - M1A1 Tanks on a Sagging Wave

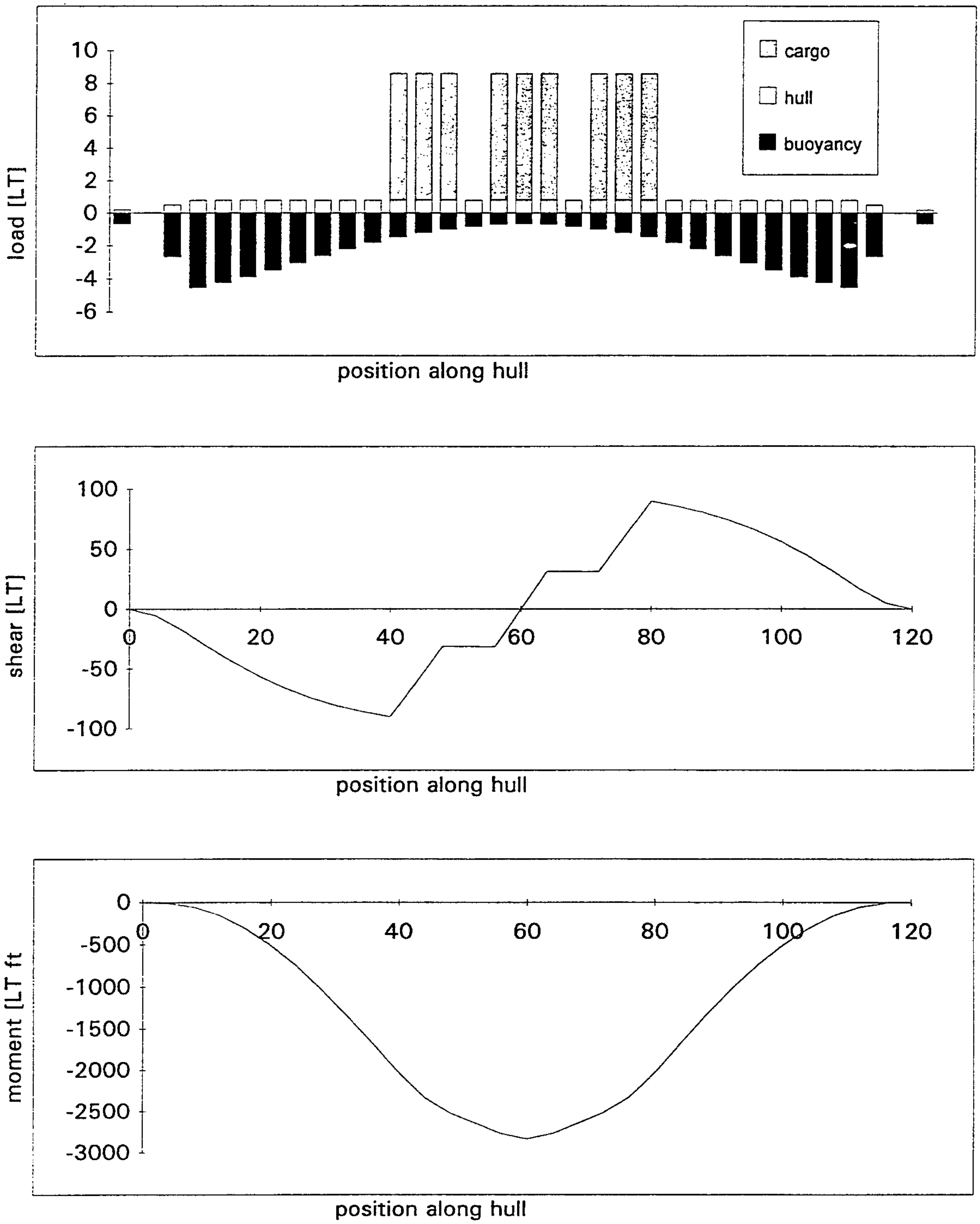
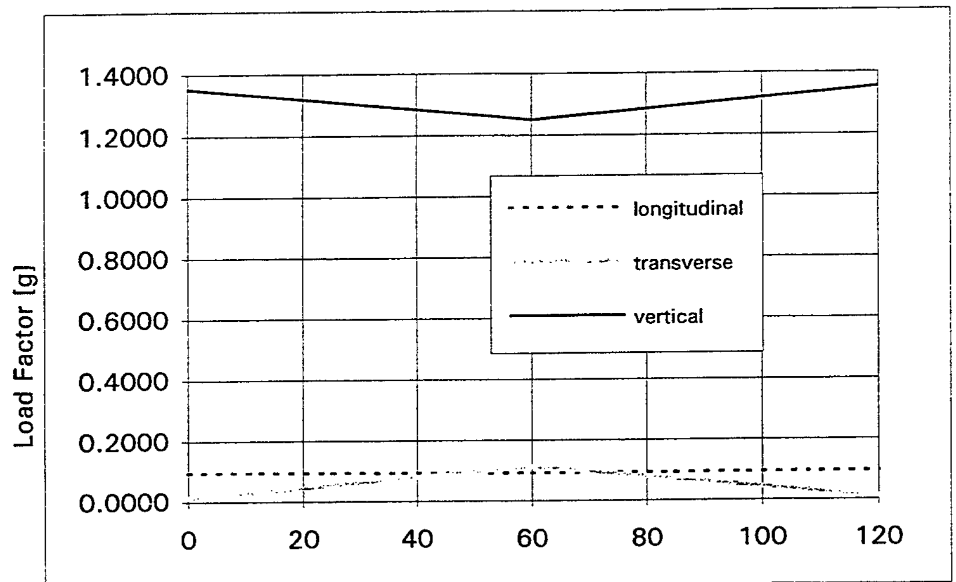


FIGURE 4.9
DYNAMIC LOAD FACTORS



position along hull [ft]

Check of Structure to Specific Loading.

Strength and stability of the bulkheads under RTCH loading have been checked using Navy Design Data sheet DDS 100-4 [21] for guidance. The scantlings provided for the ACB provide sufficient strength.

Stowage loads on the module have been checked by calculating the load carried by the lowest stowed module in a stacked configuration assuming 4 other modules stacked above it and including a dynamic factor of 1.3 to account for accelerations of the transport ship. This load was assumed to be carried only on the ISO container corner fittings and resisted by a limited area of module plate structure. Both of these assumptions are conservative.

Lifting loads have been estimated from the weight of a single module with dynamic factors included to account for transport ship motions and crane accelerations. Again the load is assumed to be carried by a limited of module plate structure as a tension load.

Resulting Scantlings.

Table 4.7 lists the resulting scantlings for the ACB module. It should be noted that the end plating of the modules as well as that plating for the rake on the end module, has been increased to 5/16". This is to provide additional insurance against damage in these vulnerable regions. Figure 4.10 shows a typical midship section. Full calculations documenting the structural analysis are included in Appendix D. Structural scantling drawings for both the center and end modules are also provided in the appendix.

4.3.2 Weight Estimate

As defined in Section 3.2 the module weight for the ACB system is limited to 30 LT (67200 pounds) to allow transportation and deployment in a manner typical of a standard 40 foot ISO container. A weight estimate has been developed using a SWBS (Ship Work Breakdown Structure) format. This provides estimates of weights for structure and identifiable outfit items. The difference between the 30 LT limit and the estimated weight is then stated as a budget weight for connections systems which are not yet fully defined.

The structural weight in the final estimate takes advantage of some tradeoffs developed for the structural arrangements as well as the use of high strength steel for the heavily loaded deck structure. These tradeoffs included:

- the use of ordinary strength steel for the deck vs high strength steel,
- weight of longitudinal vs transverse framing system,
- the use of corrugated panels to replace the stiffeners in shell and bulkheads,
- the use of a 4 web frame spacing (span for the longitudinal stiffeners) vs a 8 foot spacing,
- the use of 24 inch deck beam spacing vs 12 deck beam spacing.

TABLE 4.7
ACB LIGHTER STRUCTURAL SCANTLINGS

Plate

Bottom Shell	0.25	
Side Shell	0.25	
Transom/Headlog	0.3125	
Rake	0.3125	
Bulkheads	0.25	
Deck	0.25	H36(High Strength)

Framing

Bottom Longitudinal	L 5x3x5/16	
Side Longitudinal	L 4x3x1/4	
Bulkhead Stiffeners	L 3x2x1/4	
Transom Stiffeners	L 4x3x1/4	
Side/Bhd Transverse	L 8x4x7/16	
Deck Longitudinal	FP 15x4x5/16	H36(High Strength)
Deck Transverse Girders	FP 24x4x1/4	H36(High Strength)
Bottom Tranverse	FP 10x3x5/16	

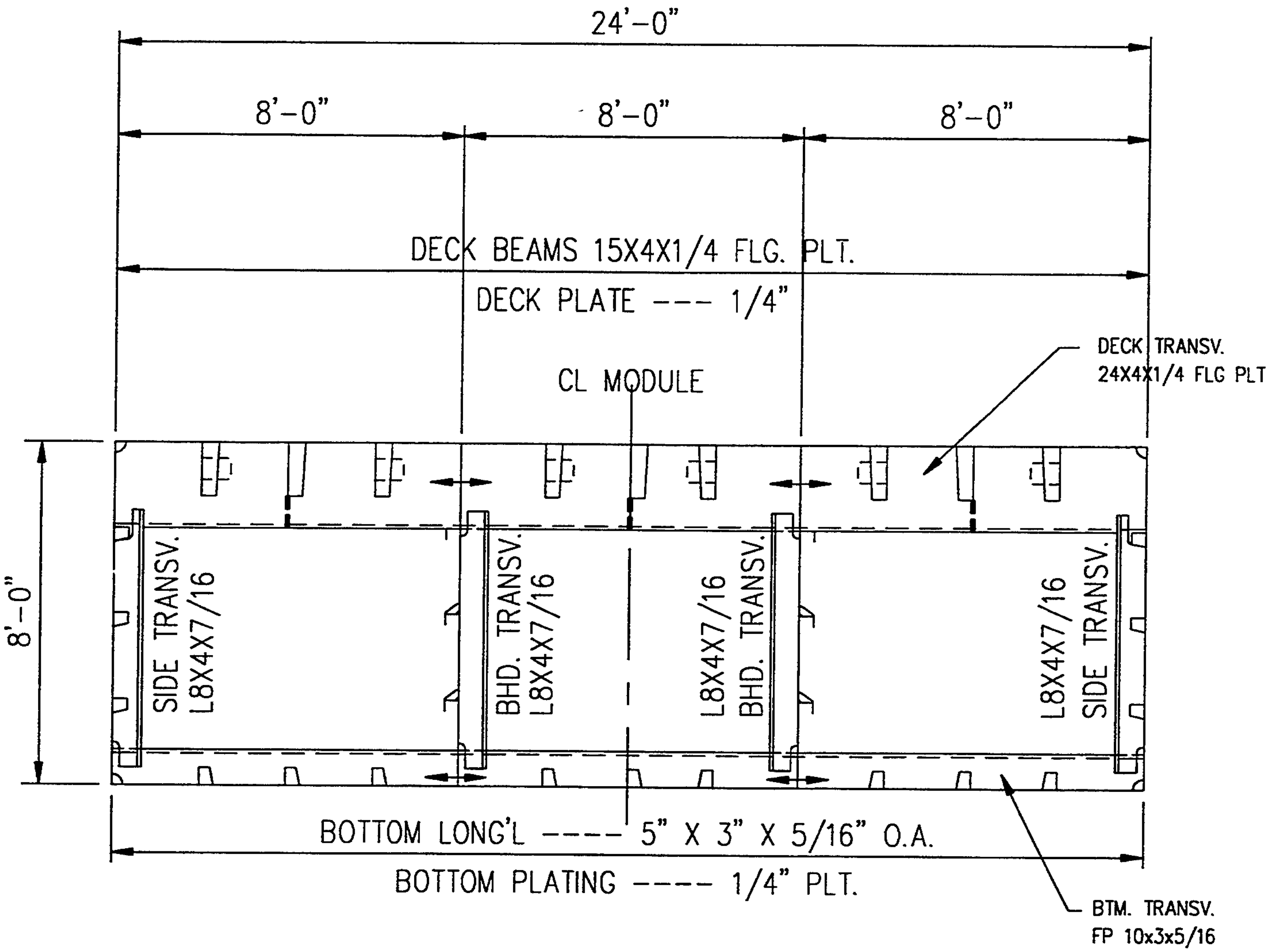


FIGURE 4.10
MIDSHIP SECTION

In each of these cases the option resulting in the least weight has been adopted.

The weight estimate also includes an allowance for paint. This has been applied as a percentage (1.5%) of the structure weight which is common practice.

Outfit weights include the estimated number of fittings which are defined and discussed more in Section 4.3.7.

Tables 4.8 and 4.9 give weight estimate summaries for the major weight groups for both the center and end modules. Full estimates for the final weights as well as the trade-offs evaluated are included in Appendix E.

Options for additional weight savings include:

- using high strength steel for all structure. This would likely allow for smaller stiffeners and transverse web frames and may result in lighter bulkhead thicknesses. Estimated savings 3000 pounds.
- reducing transom plates from 5/16 to 1/4 inch thickness. Estimated savings 900 pounds.
- reduced number of fittings.

4.3.3 Stability

As discussed in Section 3.5, stability criteria have been defined for the ACB lighter system based on general guidelines for deck cargo barges.

For intact stability the criteria contained in CFR 46 174 [7] have been used to ascertain the relative safety for the system. These criteria require a minimum righting energy, defined by the area under the righting arm curve of 15 ft degrees between 0 and 40 degree or a lesser downflooding angle. For the ACB there are effectively no downflooding points assuming the watertight access hatch is closed during loaded operations.

For damage stability, a limited set of criteria have been used. These are:

- no deck edge immersion,
- equilibrium heel after damage of less that 15 deg.
- positive range of stability after damage of 15 deg.

This limited set has been developed from typical damage criteria that in general are applicable to more stringent service requirements such as ocean going passenger vessels or naval vessels. Typical references are CFR 46, Solas 90, the MARAD Stability Letter, and NAVSEA DDS 079. The limited set of criteria defined above will provide a measure of the relative safety from a damage stability standpoint.

TABLE 4.8
WEIGHT SUMMARY FOR CENTER MODULE

Group	Weight	VCG	TCG	LCG
100 Structure	57933	4.22	0.03	20
600 Outfit	1631	5.2	0.4	20.1
Budget for Connection Systems	7636	4	0	20
Total Weight	67200	4.2	0.0	20.0

TABLE 4.9
WEIGHT SUMMARY FOR END MODULE

Group	Weight	VCG	TCG	LCG
100 Structure	57027	4.44	0.03	22.5
600 Outfit	1523	5.44	0.41	19.6
Budget for Connection Systems	8650	4	0	20
Total Weight	67200	4.4	0.0	22.1

The no deck edge immersion condition ensures maintenance of the maximum waterplane area after damage. In most stability criteria this condition relates to immersion of a "margin" line which is defined as 3 inches below the deck edge. For the ACB system, deck edge immersion is an adequate limit.

An equilibrium heel angle of 15 deg. is an operational safety condition and ensures that the cargo will not shift and that personnel can still move about the deck of the modules if required.

A positive range of 15 deg. provides the damage vessel with an amount of righting energy to withstand the effects of heel or roll angles from environmental or other causes.
Loading conditions analyzed included the following:

- a maximum cargo load condition of 200 LT with a vertical center of 53 inches above the deck (intact and damage)
- an unloaded condition for a 120 foot rigid unit (intact only),
- an unloaded condition for a 40 foot module (intact only).

The 200 LT maximum load is defined based on an analysis of typical cargo (see Section 3.4). The vertical center of gravity for the load is based on the center of gravity assumed for M1A1 tanks as given in the Sealift COR [2] for the "Tracked Vehicle". This load condition provides a worst case from both a load and vertical center point of view.

Analyzing the unloaded conditions ensure that the modules maintain adequate stability during the connection process. The stability analysis for the loaded condition is limited to the 120 foot unit since this is the largest operating rigid configuration. A causeway ferry or moored causeway made up of several flexibly connected 120 foot units is going to have greater stability reserve.

Subdivision for the ACB modules is based on a high probability of flooding type damage occurring and the likelihood of damage allowing the flooding of two adjacent compartments. As discussed in Section 4.3.1, the hull is subdivided by two longitudinal bulkheads effectively limiting the transverse extent of flooding. In addition early results from the damage stability analysis indicated a need to limit the length of any wing compartment to 16 feet. Therefore, additional partial bulkheads are provided in the wings.

The stability analysis is developed using the PC based software, GHS. The analysis includes, for each loading condition, balancing the hull loaded configuration and developing a righting arm curve for the intact case. For the maximum load case this is followed by a sequential damage and flooding of groups of two adjacent compartments along one end and a side of the 120 foot unit.

Figures 4.11 and 4.12 show the righting arm curves for unloaded 40 and 120 foot hulls in the intact condition together with an assessment of the stability criteria. Figures 4.13 and 4.14 show the righting arm curves for the intact and the worst damage case of the maximum load case. As can be seen, the ACB possesses adequate stability.

As a check on the sensitivity of the stability characteristics to load position, an additional load case was analyzed that assumed off-center loading. The maximum load of 200 LT was placed at a position 1 foot off the center line. Table 4.10 shows the results for intact and damage conditions. For the intact case the off-center load has negligible effect. However for the damage condition, several of the damage flooding cases resulted in capsize. These results indicate that the stability of the ACB system as configured is sensitive to loading position. This sensitivity may place some conditions on the loading practices. Alternatively additional subdivision could be provided.

Full calculations of these stability analyses are included in Appendix F.

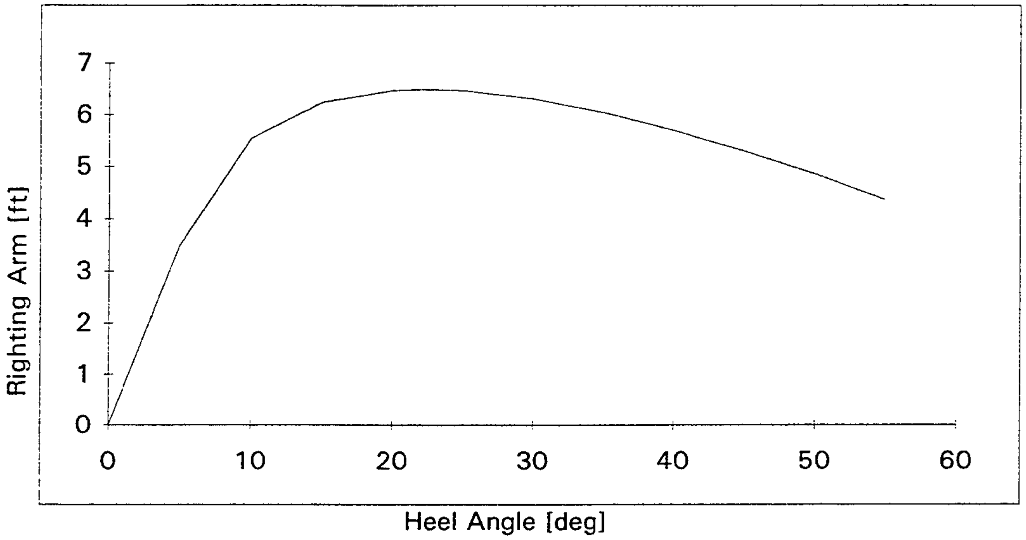
4.3.4 Resistance and Powering

The resistance/powering characteristics for the ACB Lighter system have been developed using classical naval architecture methodology. This involved developing a resistance prediction by extrapolating the results of model scale data from testing of a similar hull form. Model scale to full scale extrapolation of resistance data makes use of a methodology for separation of the total resistance into basic components: residuary or "wave making" resistance, and viscous or frictional resistance. Using Froude's Law of Comparison, the non-dimensionalized residuary resistance, given as a coefficient C_R, is assumed to be the same for geometrically similar hulls at the same speed-to-length ratio. This methodology, known as Froude scaling, is the standard means of developing accurate resistance and powering predictions during the design process.

In the absence of model test data on the specific hullform, the analysis involved deriving values of C_R from published data of similar hulls at the appropriate range of speed-to-length ratio. Research into sources for applicable resistance data uncovered very little data available. The data used for the prediction came from a set of resistance data for barges published by SNAME [6]. Of the data from this reference, the C_R values for one particular barge were used. This barge has a section area curve similar to the ACB hullform and, like the ACB modules, also has a hard transition at the bow and stern rakes. The C_R values for the reference barge are in the upper range of the values for all barges recorded in the reference.

The values of residuary coefficient from the reference information were correlated to match a speed range for the ACB of 2 to 8 knots and used as input to the PC-based computer software NAVCAD. This program was then used to develop the remaining components of resistance for the ACB, including frictional resistance to the ITTC friction line (an industry

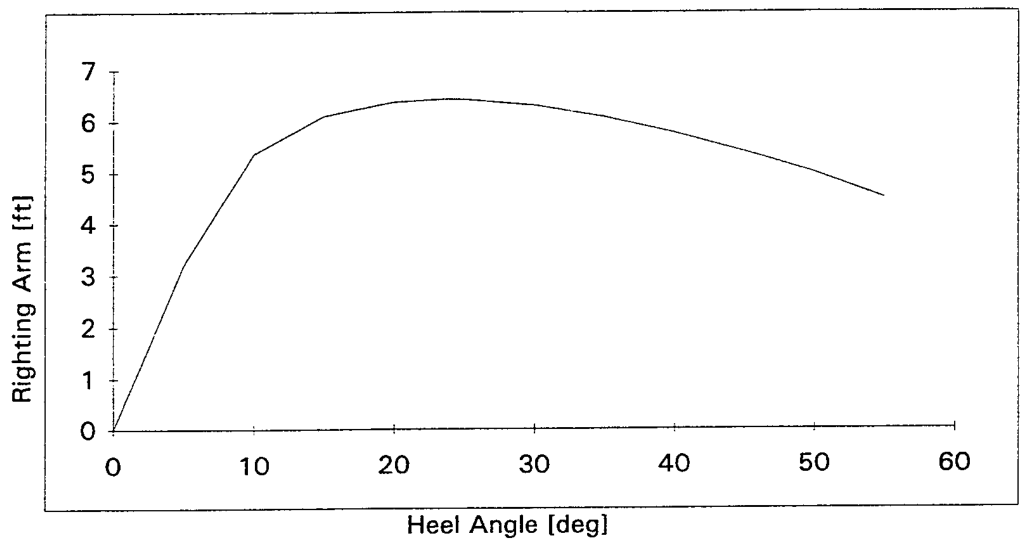
FIGURE 4.11
RIGHTING ARM CURVE UNLOADED 40 FT MODULE



Stability Criteria

Righting Area 0-40 deg 217 ft deg > 15 OK

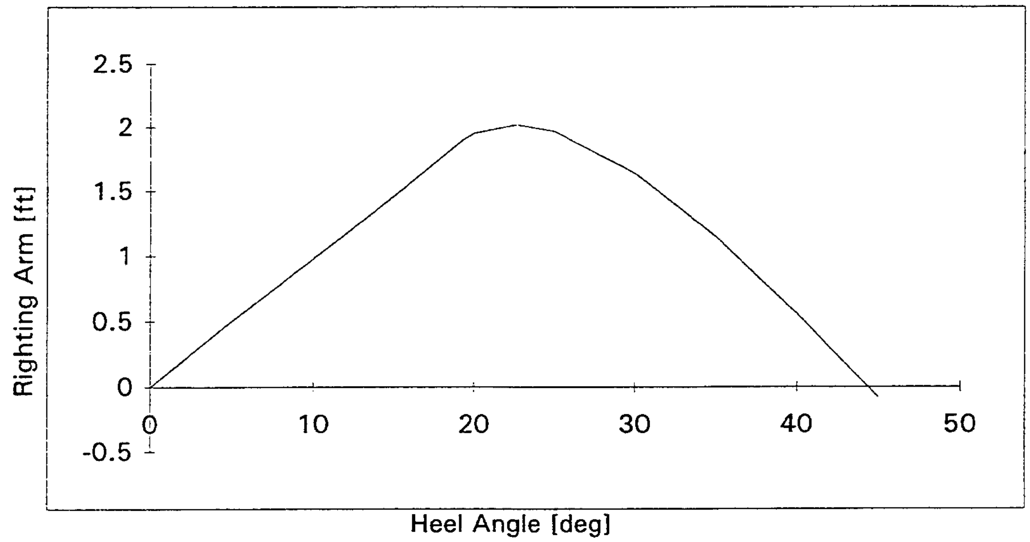
FIGURE 4.12
RIGHTING ARM CURVE FOR UNLOADED 120 FT BARGE



Stability Criteria

Righting Area 0-40 deg	214 ft deg > 15	OK

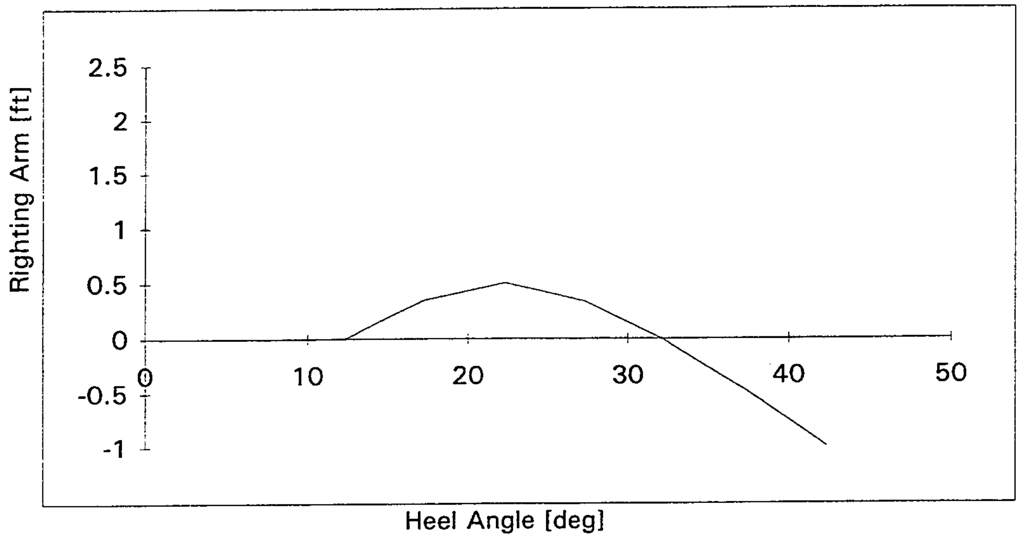
FIGURE 4.13
RIGHTING ARM CURVE FOR FULL LOAD 120 FT BARGE



Stability Criteria

Righting Area 0-40 deg	50 ft deg > 15	OK

FIGURE 4.14
RIGHTING ARM CURVE FOR WORST FULL LOAD DAMAGE



Stability Criteria

Equilibrium Heel	12 deg < 15	OK
Stability Range	20 deg > 15	OK
Min. Freeboard	0.3 ft > 0	OK

TABLE 4.10
STABILITY RESULTS FOR OFF-CENTER LOAD

Condition	Heel Deg	GM ft	Range deg	Freeboard ft
Intact	6.9	5.2	60	2.67
Damage Case 1	12.48	5.15	30	-0.13
Damage Case 2	16.2	4.94	20	-0.89
Damage Case 3	17.05	4.8	17	-0.87
Damage Case 4	Capsize			
Damage Case 5	16.1	5.42	20	0.06

Note: For definition of Damage Cases See Appendix F

standard prediction line that gives the frictional coefficient, C_f, as a function of Reynolds number for the hull) based on hullform inputs.

The results of the resistance prediction are shown in Figure 4.15.

The report on the full scale testing of an ISO Powered Module [13] gives an estimate for propulsive coefficient for the waterjet propulsion system. The propulsive coefficient, which measures the overall efficiency of the propulsion system, is given to range from 0.14 to 0.23 for the range of speeds from 4 to 8 knots. Using these numbers an estimate of the required propulsion power over the 2 to 8 knots speed range is given in Figure 4.16.

The background for the prediction methodology as well as copies of the calculations are included in Appendix G.

As an attempt to check on the quality of these results, a review was undertaken of other published sources of resistance data for barge type hullforms. SNAME has also published a set of curves, T&R 1-29 [22], which give ranges of C_R for various block coefficients and speed-length ratios. Dai [23] provides a methodology for estimating C_R for several combinations of end shape that includes square ends, flat rakes, and smooth transitions, as well as trends in C_R for changes in L/B and B/T ratios. Some full scale data results for similar hullforms are available for other modular systems, references [13], [24], and [25].

Residuary coefficients derived from the SNAME T&R and from the method by Dai are typically less than the values used in the prediction, by as much as one half. The data from the full scale trials in references [13] and [24] for total resistance of modular ferry systems compare reasonably well with the prediction. The data from the 1995 trials [25] for the Army's MCF indicate higher than the predicted resistance. It should be noted that the data in this last reference contains aspects that are inconsistent and difficult to reconcile.

Based on these comparisons it is likely that the resistance and powering estimates presented in Figures 4.15 and 4.16 will be on the conservative side. Due to the nature of the data available, the level of confidence in the absolute value of resistances and resulting power levels must be considered to be low.

Within the reference data used for this analysis, some information is available on the effects of hullform variations on the expected resistance. Both the SNAME data sheets [5] and Dai [23] show that some resistance advantage is to be gained by easing the transition at the bow and stern rakes. In particular Dai indicates that an order of a 20% decrease could be expected in resistance and therefore power for a hullform change of the type shown in Figure 4.17.

FIGURE 4.15
RESISTANCE FOR 120 FT ACB LIGHTER BARGE

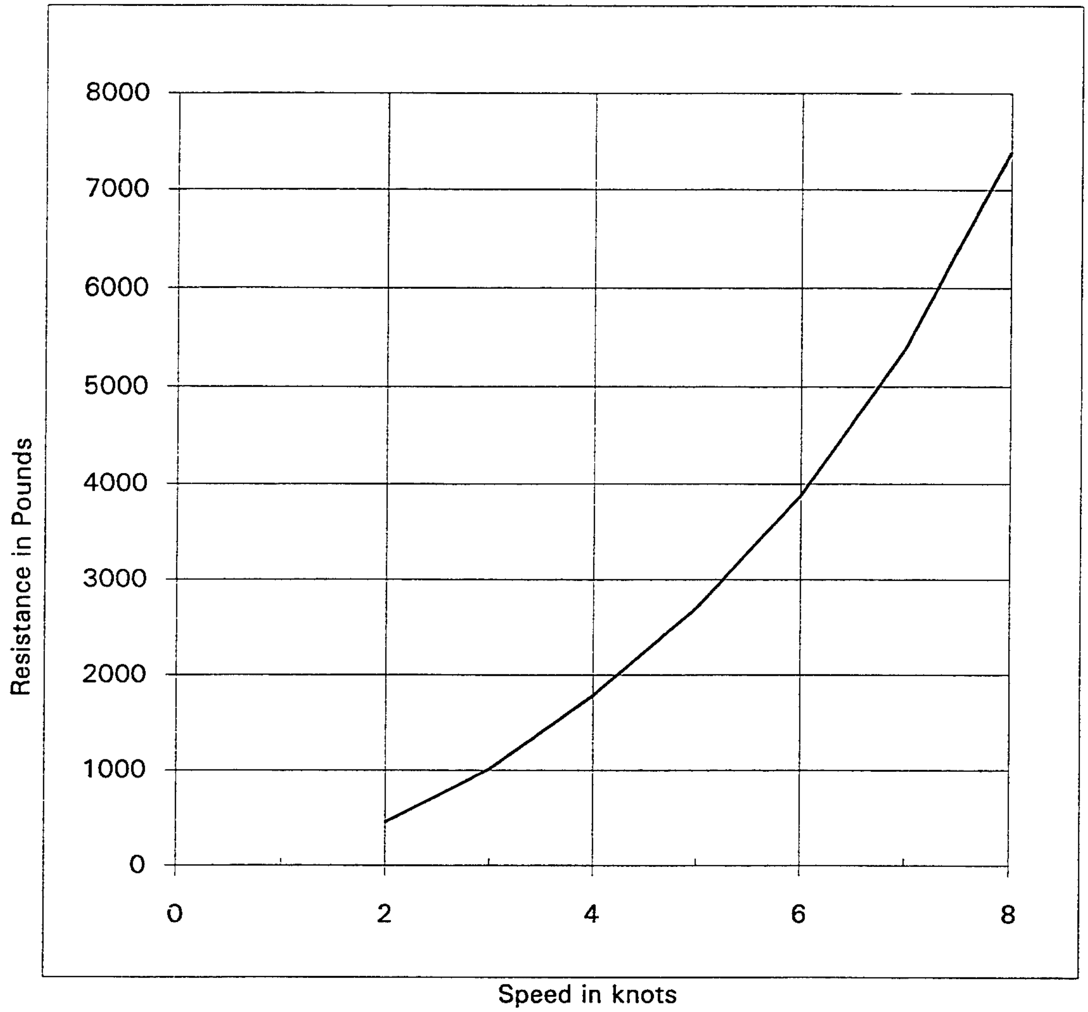
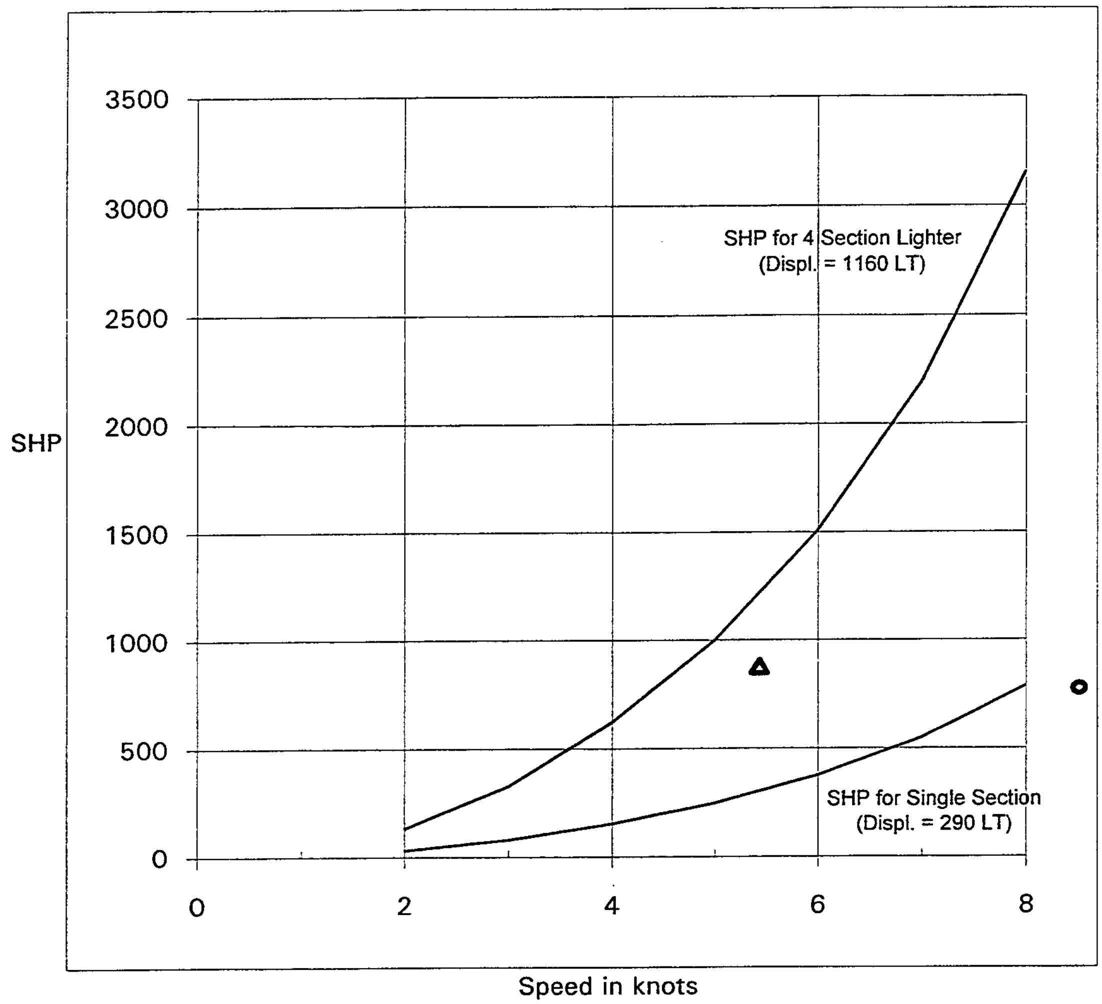


FIGURE 4.16
POWER ESTIMATE FOR ACB LIGHTERS



▲ 4 Section NL Displ. = 440 LT [Wang et. al, 24]
● PCS Displ. = 120 LT [Wang et. al., 24]

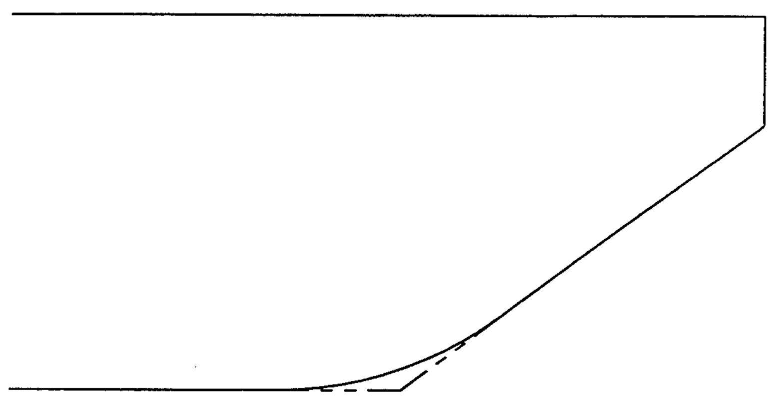


FIGURE 4.17
POTENTIAL CURVED RAKE FORM

4.3.5 Basic Motions Characteristics

As discussed in Section 4.2, a suggestion was presented to improve the motions of the hull through minor modifications of adding flare or deadrise. To review the viability of this idea a simple analysis of the basic motions characteristics of the ACB module was carried out. The analysis was performed using the 2D strip theory program SMP (the Navy's standard Ship Motions Program). The objectives of the analysis was to ascertain the relative effects of adding a moderate amount of flare or a moderate deadrise to the baseline box form.

The first step in the analysis was to "calibrate" the results from SMP against the results of an analysis of the ACB modules with the 3D analysis program MORA, Garrison [15]. The results of this comparison showed good agreement as indicated in Figure 4.18.

With confidence that reasonable results could be obtained using SMP, input models were developed to analyze the following variations and loading conditions for a 120 rigid unit:

- the baseline rectangular form at unloaded draft;
- the baseline hull but with 10 degrees of flare added;
- the baseline hull but with a 10 degree deadrise angle added;
- the same as above at a full load draft.

Figures 4.19, 4.20 and 4.21 show the hullform variations for these analysis cases together with the numerical SMP model representations. SMP models the hullform sections with splined curves. For the ACB hullform and variations the hard points at the chine are approximated by a very tight area of curvature. The "calibration" runs against the MORA analysis indicate that in general these approximations do not effect the motion results.

The results of the analysis indicate that the addition of moderate flare or deadrise has insignificant effect on the hull motions. Figures 4.22, a,b, and c plot the results for heave pitch and roll motions at the full load draft, showing almost no difference in motions between the three hull variations. Similar results for the unloaded draft were found. Figure 4.22c shows some increase in roll for the hull with deadrise added. This is felt to be a function of the modeling approximation.

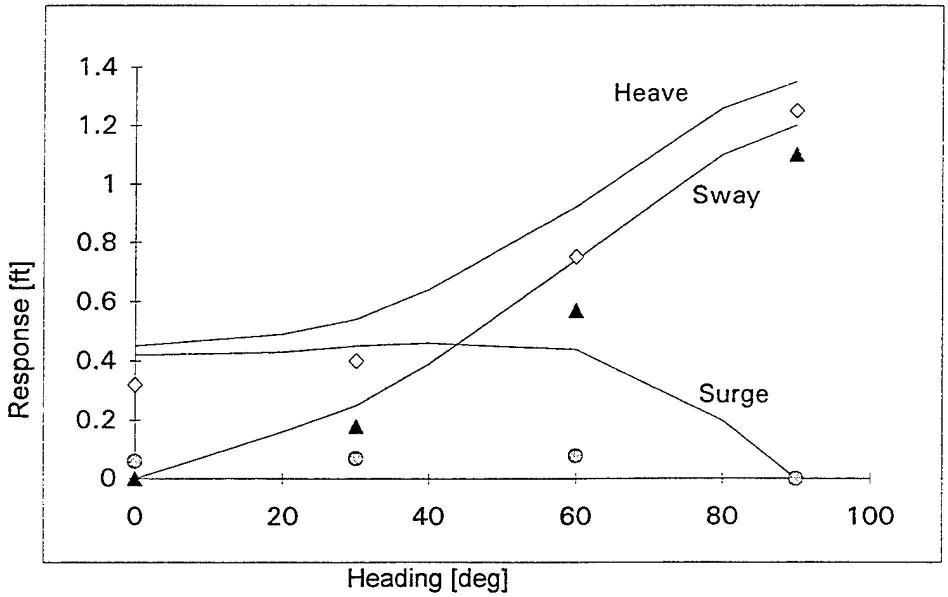
Full SMP output documentation for the analyses is provided in Appendix H.

4.3.6 Hullform and Module Configuration

As identified in Sections 4.1 and 4.3.5, several hullform/module concepts were reviewed in the course of the research effort.

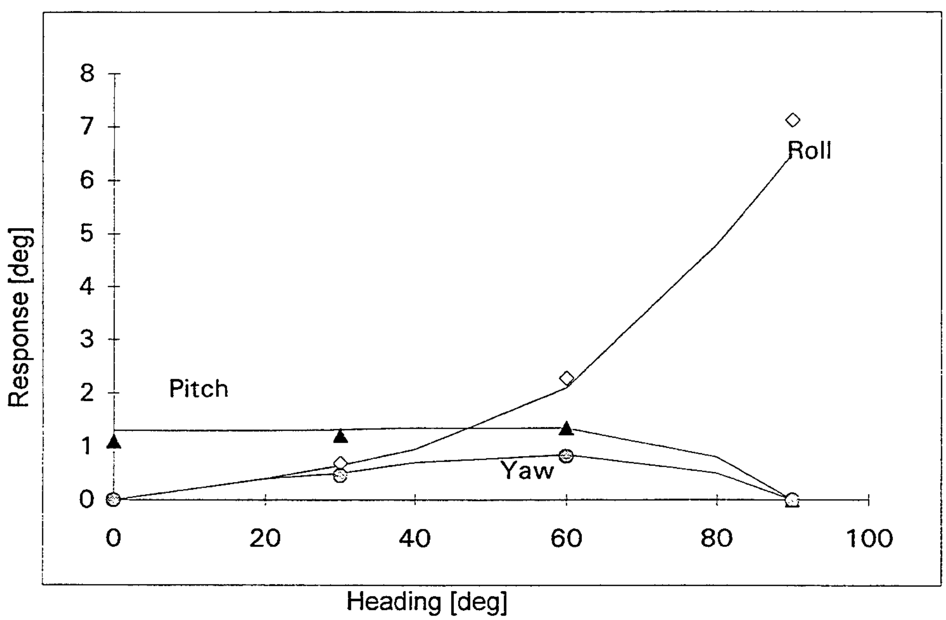
In Section 4.1, a comparison was made between monohull and catamaran type of hullforms. The results indicated little of no advantage to be gained by a catamaran form. In Section 4.3.5 the application of moderate flare or deadrise were reviewed. Again no significant

FIGURE 4.18
BENCHMARK WITH GARRISON'S RESULTS FOR 3 MODULES



a) Heave, Sway, and Surge

Legend
Garrison [15]
SMP



b) Roll, Pitch, and Yaw

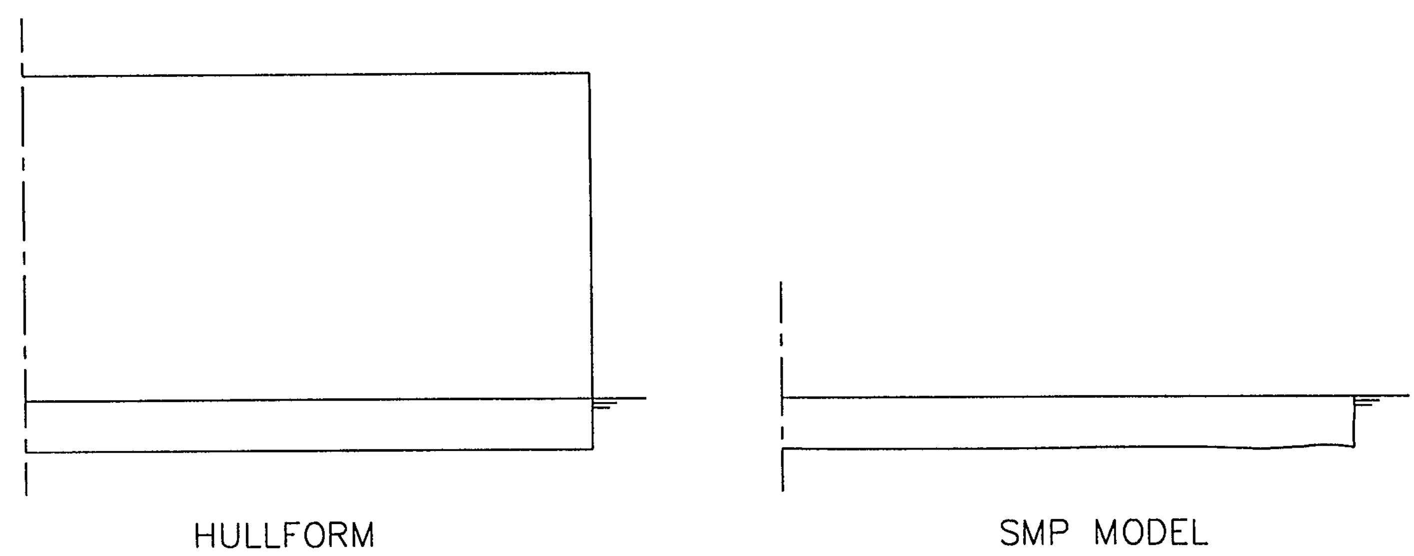


FIGURE 4.19
BASELINE RECTANGULAR HULLFORM

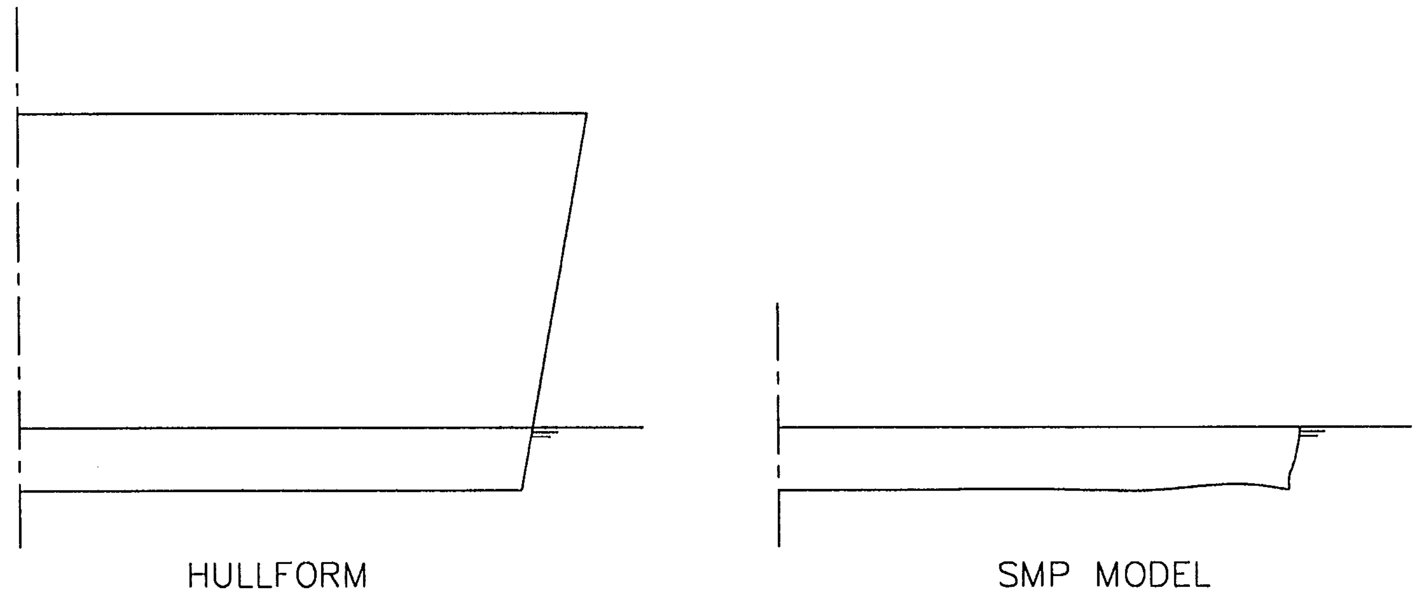


FIGURE 4.20
ADDITION OF MODERATE FLARE

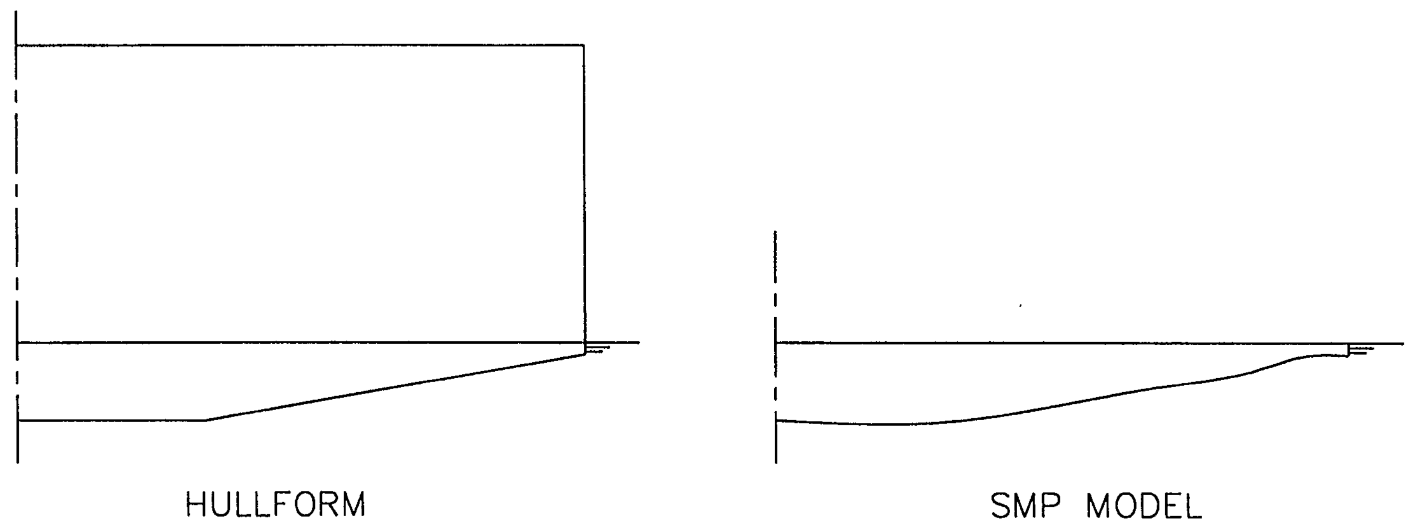
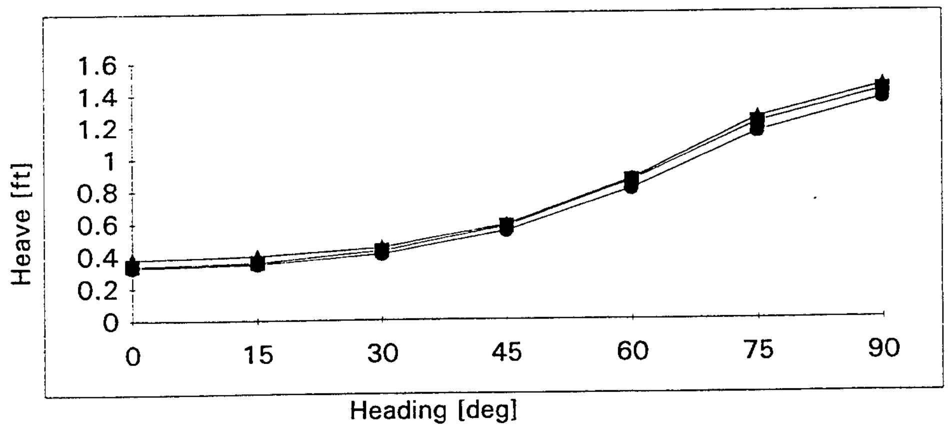
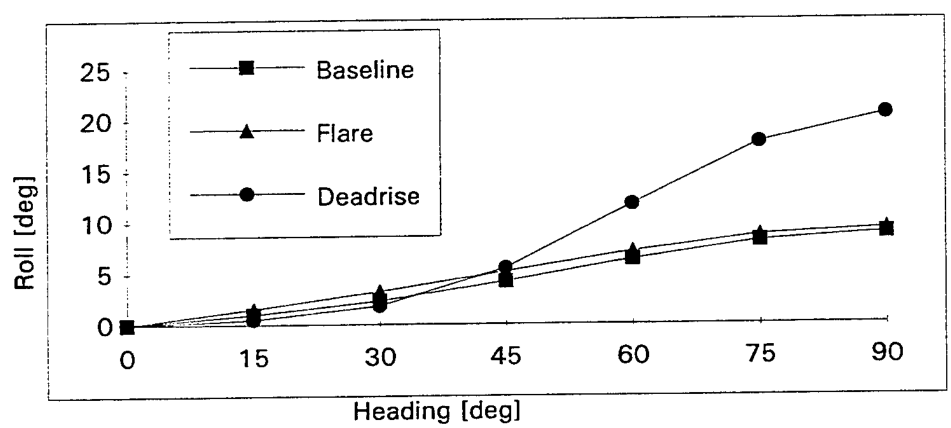


FIGURE 4.21
ADDITION OF MODERATE DEADRISE

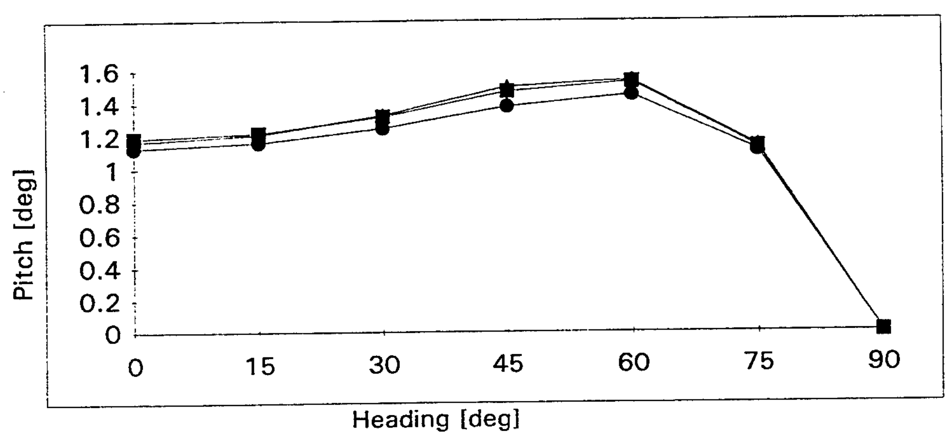
FIGURE 4.22
MOTION EFFECTS OF ADDED FLARE OR DEADRISE



a) Heave



b) Roll



c) Pitch

advantage could be shown. The results of these evaluations and analyses suggest that no advantage is to be gained by deviation from the simple rectangular form.

Two main module types are required to "build" all of the various rigid and flexible types of units to meet the operations of the ACB Lighter system. These combinations are described briefly in Section 3.5. The two module types consist of a center module, designed to allow for rigid connection at each end to other modules, and an end module, designed to allow for a rigid connection at one end and a flexible connection at the other. These two modules are connected in combinations of one center module and two end modules to form the next level of basic unit consisting of a 120 foot rigid unit.

Figure 4.23 shows the general geometry for the center module. This has overall dimensions of 40 feet length, 24 feet breadth, and 8 feet height. Simple hard edges form the intersection at each pair of faces, and the module itself is thus a simple rectangular box. Each end of the module has 2 recesses, 1'-0 1/2" wide by 1'-0" deep for the full height of the module. These recesses are provided to accommodate the container cell guides for stowage of the module in the hold of a T-ACS or commercial container ship.

Figure 4.24 shows the geometry of the end module. This has overall dimensions the same as the center module and differs from the center module only in that it has a simple flat rake for the full width of the module at one end. This rake extends from 2'-4" below the deck to a point 7'-8" from the end at the bottom shell, forming a 36.5 degree sloped surface. The rake angle geometry is based on minimizing the effects on the major module structure which is arranged on 8 foot spacing. The rake angle has not been optimized from a resistance standpoint. This raked end is designed to allow freedom of movement at the flexible connection as well as providing for reduced resistance as the connected units move through the water. The 2'-4" is provided to allow sufficient depth at the end to accommodate the flexible connection system components, while still having the vertical face at the end of the module above the waterline at the full load draft. The ends of the module are also provided with container cell guide recesses.

The transition between the rake and the bottom forms a hard point. As discussed in Section 4.3.4, further development of the ACB may find some advantage in softening this transition, as a means of reducing resistance, and providing at least a partial curved rake. Other aspects of the geometry of the raked end can also be revised if required, once additional information on connection systems is available.

Figure 4.25 shows one option for the general geometry of a beaching module. As discussed in Section 3.4, this specialized unit is required to provide the beach interface for the ACB system in either a beaching lighter or moored causeway configuration. This unit has a foldable beach end section designed to provide a ramped transition from the deck of the ACB assembly to the beach. The potential configuration shown has be developed to the level of general geometry considerations only. This geometry is based mainly on an

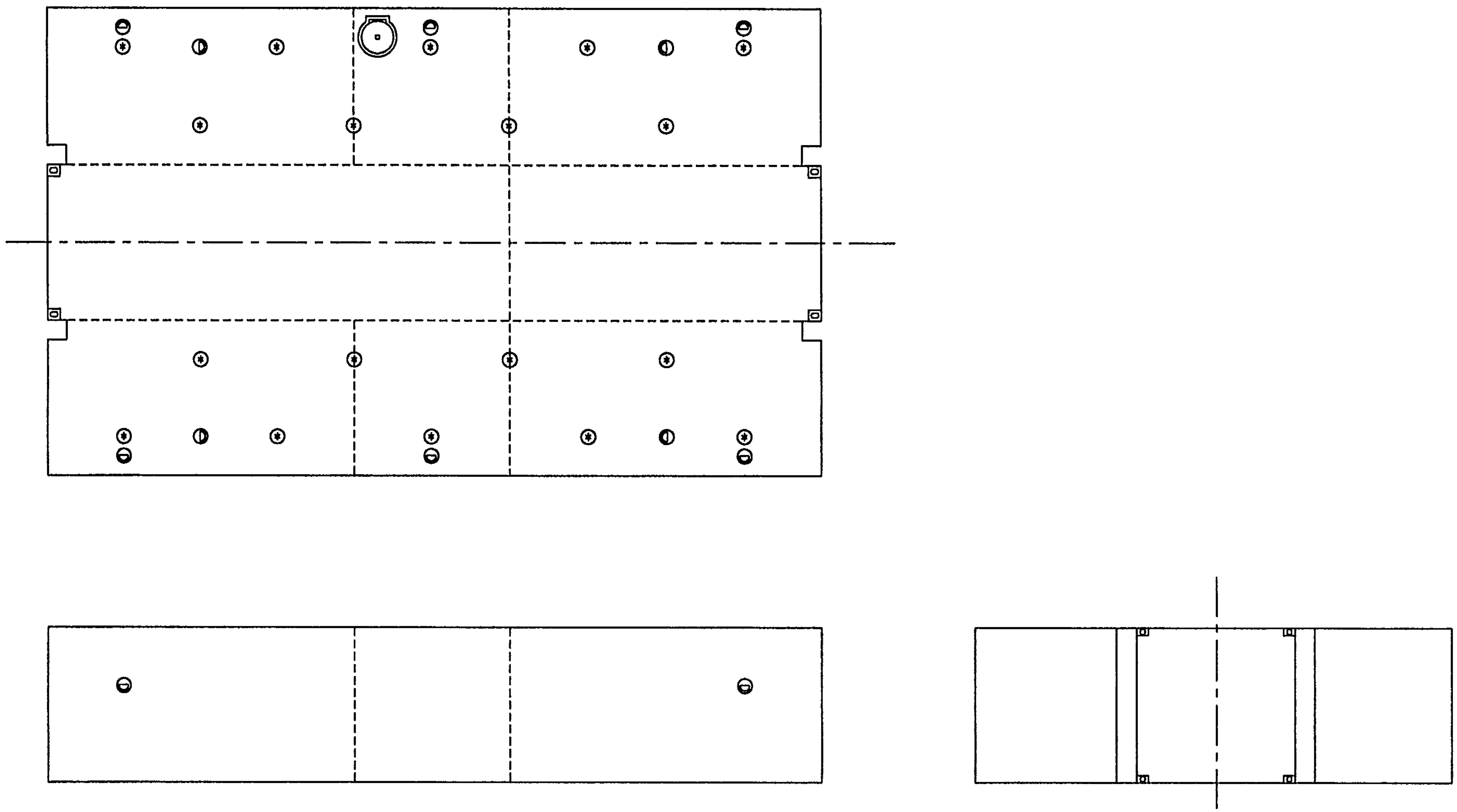


FIGURE 4.23
CENTER MODULE

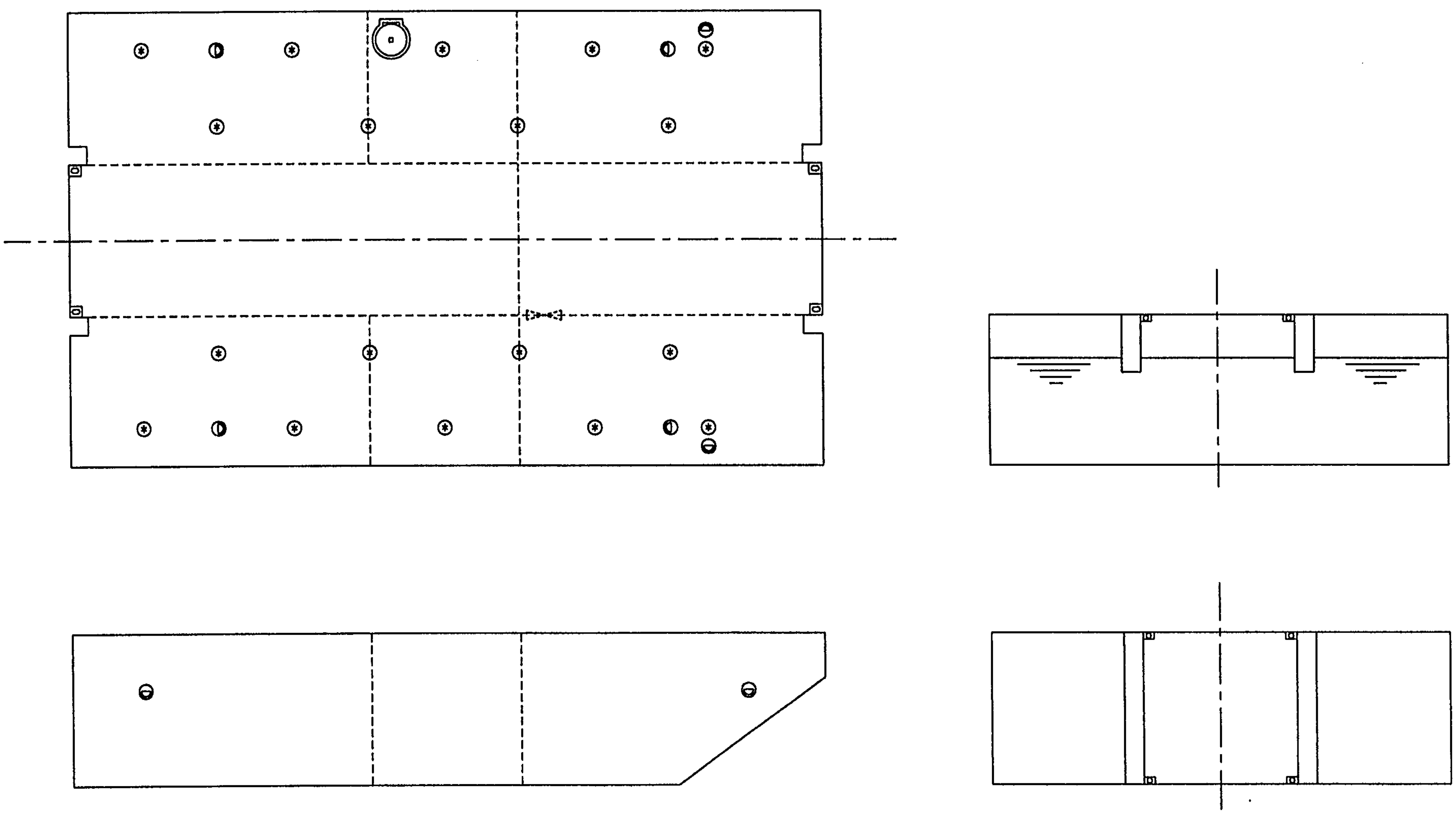


FIGURE 4.24
END MODULE

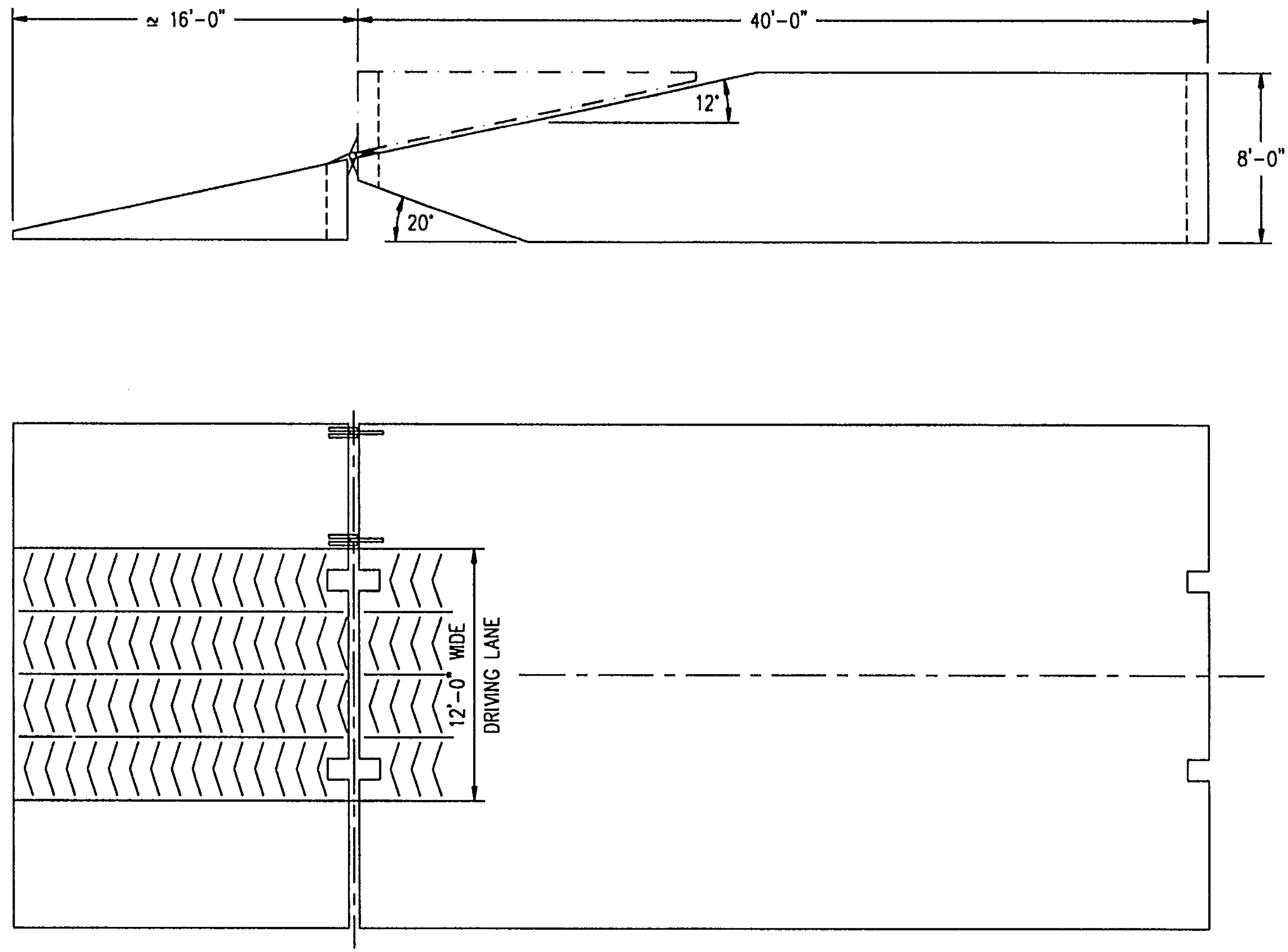


FIGURE 4.25
BEACHING MODULE

assumed maximum ramp breakover angle of 12 degrees, similar to the requirement for ramps contained in the Sealift COR [2].

The configuration shown incorporates a beach section that is approximately 16 feet in length connecting to the module with four hinge assemblies. The hinge axis is required to above the ramp surface to facilitate the required 180 degree fold. For this reason the hinges have been shown located outboard of a designated 12 foot wide drive lane to avoid damage from rolling stock. The 12 degree ramp angle results in a sloped portion on the module of approximately 18 1/2 feet in length.

The underside of the module at the ramp end has a 20 degree flat rake. This is provided to reduce resistance in operation. It is assumed that the module would be deployed with the beach section locked in the folded configuration. If the beach module is left unloaded then it would float at a level that would have the rake surface above the waterline. This would serve to reduce the additional resistance due to "dig in" that has been reported in full scale trial of similar systems (see reference [25]).

This beaching module will require further development particularly in regards to:

- how the beach section will be unfolded;
- a locking arrangement;
- hinge design;
- specific structural arrangement and scantlings;
- incorporation of ISO container fittings for lifting on T-ACS or container ships.

Other geometry configurations are possible and may be required dependent on how the beaching facility is to be used in various operations and beach environments.

4.3.7 Hull and Deck Outfit

Hull and deck outfit for the ACB lighter modules is required at a level to allow the system to interface with other logistics assets in aspects of the mission related to transportation, deployment, and cargo handling. These interfaces have been identified in Section 3.4.2. Special outfit as also required on the modules to allow access below decks for maintenance, inspection, and possibly stowage requirements.

Outfit items and arrangement are shown on module general arrangement drawings included in Appendix I.

Access below decks is provided by a single flush watertight hatch. The hatch is located on one outboard edge of the modules near to a bulkhead. The hatch is equipped with a vertical ladder running down the bulkhead. Access to other compartments is through bolted watertight access manholes located in the watertight bulkheads. The module depth of 8 feet allows unhindered movement about the compartments in a standing position.

Adequate access is thus provided to each compartment while minimizing the number of hatches through the deck. By providing only one hatch and placing it outboard, reduces the chances of cargo operations damaging the water tight integrity of the deck. The hatch is a flush mounted unit operated with a key similar to the hatches on the existing NL system Powered Causeway Section (PCS).

This arrangement provides the simplest means of achieving access to each of the compartments while avoiding placing fittings on the sides or ends of the modules where they are susceptible to damage. This arrangement assumes that the compartments of the module are normally unoccupied and that bulkhead manholes remain closed while the ACB is in operation. Other arrangements are possible that would provide more convenient access (such as more deck hatches), but at the price of greater potential for leakage.

Fittings provided for deployment and stowage configurations include:

- ISO container corner fittings at the corners of the 8 foot wide center portion of the modules. Four such fittings will be fitted to the top of both main module types. Four fittings will also be provided for the bottom of the center module, while two will be fitted on the bottom of the end module. The corner fittings will be located within the tolerances specified in ISO standard 668 [14]. These fittings provide the capability of lifting the modules with a standard ISO 40 ft container spreader as well as potentially using container deck fittings;
- 4 recessed heavy 'D' rings in the top of each module to provide lifting points on transport vessels not equipped with ISO container spreaders;
- 2 recessed heavy 'D' rings on each side of the modules to provide lashing points for stowage on the decks of ships.

Fittings provided for mooring and anchoring include:

- 3 flush type 'D' rings port and starboard for the center module;
- 1 flush type 'D' ring port and starboard for the end module.

Cargo tie-downs are provided in two rows port and starboard along the full length of both module types. The rows of fittings are located 6 and 10 feet off centerline on 8 foot longitudinal centers. The inboard row is offset longitudinally by 4 feet. This provides a tie down grid that should service any loading configuration. The cargo tie-downs shown are typical "cloverleaf" flush socket type oriented at 45 degrees to the centerline of the module. These are standard fittings for use in cargo tie-down operations and are intended to be used with "elephant hook" type lashings.

The fitting arrangement has been developed on the basis that the ACB system will need to meet the same types of requirements as the existing NL system. The arrangement provided has not been optimized to specific loading arrangements. The objective has been to identify and provide fittings that meet the basic needs of operational interfaces. Other types of

fitting are possible from those proposed. The final choice of outfit will require a more detailed analysis of interface requirements in conjunction with specific operational data.

In addition to the basic outfit arrangement shown other types of fittings may be required including:

- drain or dewatering fittings;
- vent fittings for compartments;
- sounding fittings;
- fenders;
- connection system fittings.

The requirements for these will need to be developed based mainly on the expectations for specific operational practices.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Phase I Significant Findings

The Phase I developments have provided an ACB module description to a level which addresses the majority of characteristics to at least a first level. The following are identified as the major results of the research together with discussion of their impact on the development as a whole.

Hydrodynamics and Seakeeping

Several options were reviewed as potential means of attenuating the motions of the modules, ranging from simple modifications to the hullform to the addition of complex damping systems. The addition of moderate amounts of flare or deadrise were found to have no effect on the motions as was the adoption of an alternate catamaran hullform. The fitting of an open truss system or a passive stabilization tank, while offering motion reductions, were determined to impose significant penalties on other characteristics of the ACB system. Only the use of attached perforated plates showed any significant promise.

The specific configuration of attached plates analyzed resulted in a reduction of roll motions of up to 30%. Similar reductions of heave motions are assumed to be possible with other configurations. If it is determined that a 30% reduction in motions produces any real advantage in the ability to make safer and quicker connections, then the attached plate approach should be further developed.

Options for Module Geometries

The conceptualization effort in Phase I identified several potential alternative forms for the module. For Phase I these were determined to not warrant deviation from the rectangular form, which would require a major redirection of effort without sufficient evidence of advantages. If these alternatives are of interest to NFESC, the development of one or more of them could be carried out in parallel to the rectangular module to a level the would allow for a proper evaluation against real advantages to be gained.

Structure

The structure for the modules has been developed on the basis of conventional barge construction arrangements and design philosophy, and with a minimal use of high strength steel. As part of this development the deck structure has been sized assuming that a certain amount of dishing, or permanent set, is acceptable. The analysis predicts, in what has been determined to be a conservative sense, the amount of dishing that will occur over time. If an allowable permanent set criteria is determined not to be reasonable, then a rearrangement of the deck structure will be required with an associated increase in structure weight. As mentioned in the discussion of the structure, the capacity of the structure to

withstand the operational loading is not effected by the presence of a marginal amount of dishing in the deck. The suitability of an allowable permanent set criteria must, therefore, be determined from an operational standpoint.

The structural analysis has made use of high strength steel on a limited basis for the heavily loaded deck only. The use of high strength steel will have a marginal material cost impact but little labour cost impact. The use of high strength steel for all structure will likely result in further weight savings and should be considered.

Weight

The analysis of the weight of the modules indicates that, with a conventional structural arrangement, the weight, excluding connection systems, amounts to nearly 90% of the 30 LT weight limit. This means that only 10% is available for connections systems weights if the 30 LT limit is to be met. It is possible that this allowance is insufficient to handle the connection systems. If this is the case, options for reduction of module weight need to be investigated.

The largest portion of the module weight is the structural weight and of this approximately 40% is in the deck structure. Any options for additional weight savings should consider means of reducing the deck structure weight, possibly through the use of non-conventional framing systems or materials.

Stability

The analysis of stability for the system has indicated that, in general, the barge form of the modules has good stability characteristics. The damage stability analysis, however, has indicated that the 120 foot rigid unit, as configured, has some sensitivity to load positioning, in that if the 200 LT maximum load is placed one foot off the centerline capsize will occur under certain damage scenarios. This effectively places a restrictive limitation on the load placement to avoid potential problems. If such a limitation places too great a penalty on loading operations then alternative subdivision arrangements need to be considered.

Resistance and Powering

Of all the analyses performed as part of the development, the resistance/powering prediction carries the least reliability. This is a function of the quality of the data available as well as a characteristic of barge forms which makes extrapolation of resistance values for differing proportions difficult. For most transportation systems, powering is of critical importance since it effects operation costs. If this is true for the ACB system, as it likely is, then additional effort needs to be expended to improve the prediction.

Hullform

The analysis of aspects of the ACB mission that effect module hullform indicated that no advantage is to be gained from deviation from a rectangular cross section. The only outstanding issue relates to the rake form of the end module. The end rake should be reviewed further from the standpoint of resistance, as discussed above, and the effect on the structural arrangement.

The beaching module shown in the report is a slight departure from the general configuration provided at the outset of the Phase I effort, which had an articulating end. The relative advantages of either configuration requires a more complete review of operations of beach-end lighterage in transit conditions and for a variety of beach environments. The final choice of geometry will then be required to be developed to a level consistent with the two base modules.

Outfit

The level of outfit provided is based on a first look at the requirements without optimization. Cargo tie-downs should be reviewed from the standpoint of loading configurations and load patterns to identify whether the tie-down arrangement is adequate or excessive.

Access fittings have been provided based on minimizing through-deck fittings as a way of reducing potential leakage. This arrangement needs to be reviewed, together with the need for other fittings, from the standpoint of maintenance, inspection, and other operational aspects.

The design for the ACB modules as shown on the drawing has not explicitly considered the connection systems since these are not yet fully defined. It is clear that the final size and configuration of the connection systems will have an effect on the module design in areas such as structural arrangement, deck layout, and to some extent module form.

5.2 Recommendations for Phase II

Based on the results from Phase I, several areas warrant consideration for further development.

Review of Other Configurations for Attached Perforated Plates

The hydrodynamic analyses performed under Phase I established the effectiveness of attached perforated plates in damping the roll motions of the modules. The research also indicated that other modes of motion could be similarly improved with other configurations of plates. To explore this area further would require:

- model testing to get good data for several configurations of plate attachments including verification of the already analyzed vertical orientation,
- numerical modeling to review various alternatives.

Evaluation of Other Module Geometries

The conceptualization process identified alternative module geometries that show potential for addressing specific mission requirements. These module geometries could be developed further to a level that would allow for a proper evaluation against real advantages to be gained.

Investigation of Non-Conventional Deck Structural Systems

This would involve a review of structural systems and material with an aim of providing weight reductions for the heavily loaded deck. Non-conventional alternatives would be reviewed together with analyses of the effects on weight, cost, and construction complexity.

Resistance Characteristics

To further the understanding of the important resistance characteristics of the system requires a refinement of the data to allow reliable predictions. This would involve a comprehensive model test program to derive valid resistance coefficients for the specific ACB configuration, to optimize the end form, as well as to quantify the effects of multiple units connected as an assembled lighter.

Review of Alternatives for a Beaching Module

To define an optimum configuration for the beaching module, several alternatives would be developed and analyzed with respect to operational issues in transit conditions. The review would include loading and cargo operations together with the module's effect on the overall resistance of a lighter to which it would be attached.

6.0 REFERENCES

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16 Jamieson, W., Mogridge G., "Model Tests of a Floating Breakwater Dock", International Symposium on Waves - Physical and Numerical Modeling, University of British Columbia, 1994.

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18 Van den Bosch, J.J., and Vugts, J.H., "Roll Reduction by Free-Surface Tanks:, TNO Report No. 83 S, Netherlands Ship Research Center, Apr. 1966.

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22 Moss, J.L., and Townsend, C III, "Design Considerations and the Resistance of Large Towed Seagoing Barges", Technical and Research Bulletin 1-29, SNAME, New York, Sept. 1972

23 Dai, R.T.Y., et. al., "Offshore Construction Barge Performance in Towage Operations", Offshore Technology Conference, OTC 81, Houston, 1981.

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APPENDIX A

Technology Review Technical Information

[Note: The following documents included in the original document have not been included in this Contract Report; however, the references have been provided to facilitate retrieval.]

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Sectional Barges

Green Bay Structural Steel, Inc. 865 Lombardi Ave., P. O. Box 10327, Green Bay WI 54307-0327. Tel: 414-435-3747. Fax 414-435-2611.

Commercial Dock Systems

Radisson Design, Inc., C P 160, Ste-Agathe-des-Monts, Quebec, Canada J8C 3A3. Tel: 800-361-3625, 819-326-7041. Fax 819-326-6029.

TIECO Breakwater Model Tests

Jamieson, W., Mogridge, G., and Williams, D. (1994). "Model Tests of a Floating Breakwater Dock," paper presented at the International Symposium on Waves--Physical and Numerical Modeling, The University of British Columbia, Vancouver, British Columbia, Canada, Aug 1994.

Bourgon Lafleur Floating Breakwater

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Bar Harbour Floating Dock

Cornett, A. M. (1988). Analytical Modelling of a Restrained Floating Body as a Single Degree of Freedom Oscillator, National Research Council Canada, Division of Mechanical Engineering, Hydraulics Laboratory, Technical Report TR-HY-022. Ottawa, Ontario, Canada, May 1988.

Floating Airport Structures

Mamidipudi, P., and Webster, W. C. (1994). "The Motions Performance of a Mat-like Floating Airport," in Proceedings of the International Conference on Hydroelasticity in Marine Technology, Trondheim, Norway, May 1994. College of Engineering, University of California, Berkeley CA.

Lee, S. and Webster, W. C. (1994). "A Preliminary to the Design of a Hydroelastic Model of a Floating Airport," Proceedings of the International Conference on Hydroelasticity in Marine Technology, Trondheim, Norway, May 1994. Dept. of Naval Architecture and Offshore Engineering, University of California, Berkeley CA.

Semi-Submersible Bridge Concept

Neil Bose, Ph.D., P.Eng., Professor and Director, Ocean Engineering Research Centre, Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St. John's, NF, Canada A1B 3X5. Tel: 709-737-8804/8805. Fax: 709-737-2116. E-mail: nbose@engr.mun.ca.

Passive Stabilization Tank Systems

Bass, D., Friis, D., Greening, D., and Weng, C. (undated). "Passive Roll-Tank Stabilisation for Small Fishing Boats," Faculty of Engineering, Memorial University, St. John's, Newfoundland, Canada.

Flume Stabilization Systems, A Division of Maritime Tanksystems International, Inc. 7 Oak Place, Montclair, New Jersey 07042. Tel: 201-509-1530. Fax; 201-509-8819.

Modular Barge System

Neil Lampson, Inc., P. O. Box 6407, Kennewick WA.

SELECTED REFERENCES FROM THE TECHNOLOGY REVIEW

Jaunet, J.P. et. al., "Behaviour at Sea of Interconnected Structures," 3rd International Congress on Marine Technology, Athens, May 1984.

Motter, L.E., "Extreme Values of Motion from RO/RO Discharge Facility Experiments and Trials," David Taylor Naval Ship Research and Development Center, TM-15-86-157, Bethesda MD, July 1986.

Denise, J-P. F., "On the Roll Motion of Barges," Royal Institute of Naval Architects, 1982.

Patel, M.H., Brown, D.T., "On Predictions of Resonant Roll Motions for Flat-Bottomed Barges," Royal Institute of Naval Architects, 1985.

"Hydroelasticity in Marine Technology," Proceedings of the International Congress on Hydroelasticity in Marine Technology, Trondheim 1994, O. Faltinsen et. al. Ed., A.A. Balkema, Rotterdam, 1994.

APPENDIX B

AQWA Analysis Documentation

AMPHIBIOUS CARGO BEACHING LIGHTER DEVELOPMENT - PHASE I

FINAL REPORT

APPENDIX B

Appendix B contains the following documentation of the AQWA hydrodynamic analysis.

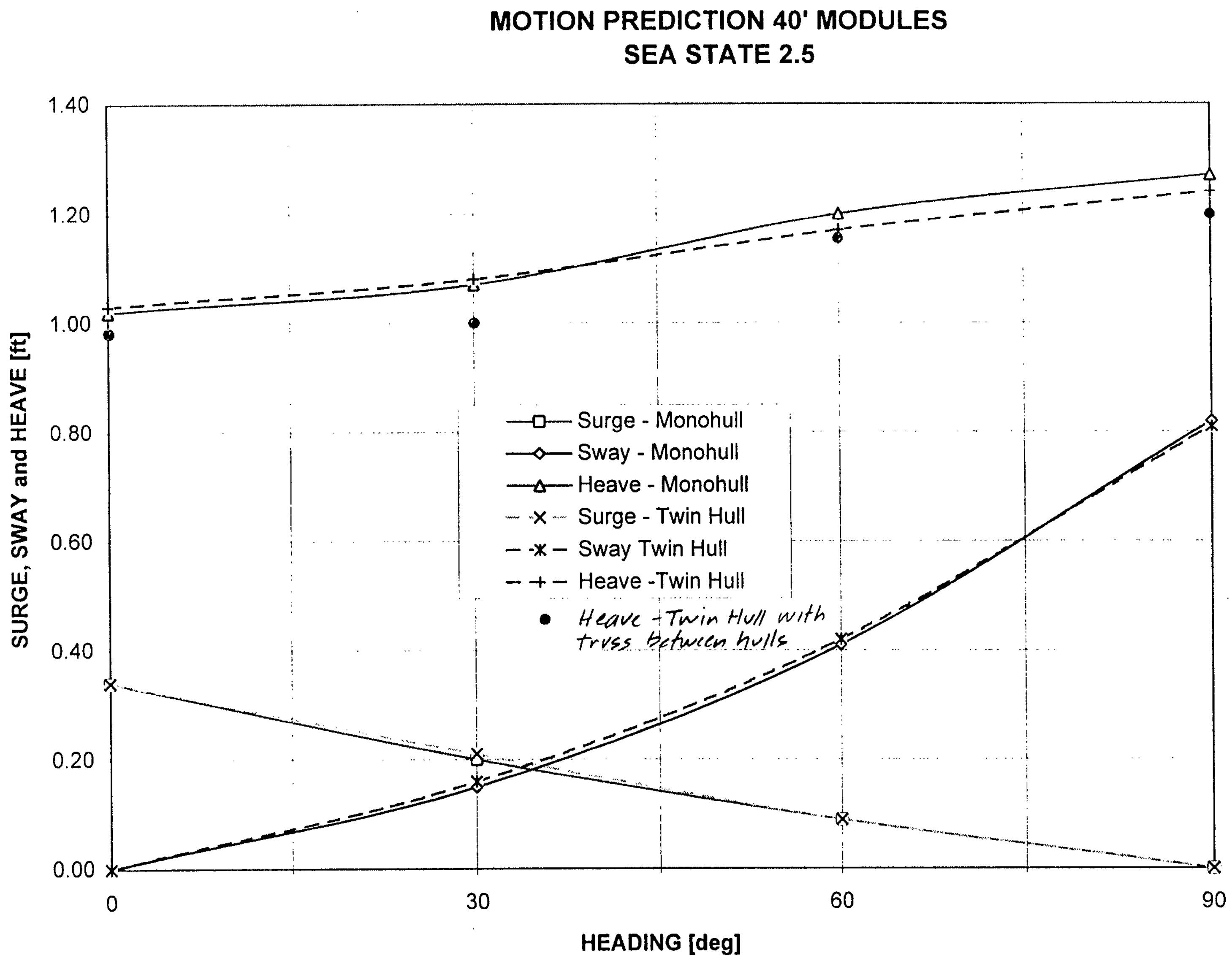
- output results in graphical form together with mark-ups for review of options for attenuating motions;
- sample calculations for the spectral motions response using the AQWA generated RAO's;
- Example model plot for the 40 foot monohull model;
- Example AQWA output (in an excerpted form) for the 40 foot monohull model;
- 3.5 inch diskette containing full AQWA documentation for other models analyzed including:

  input files
  output files
  plot files

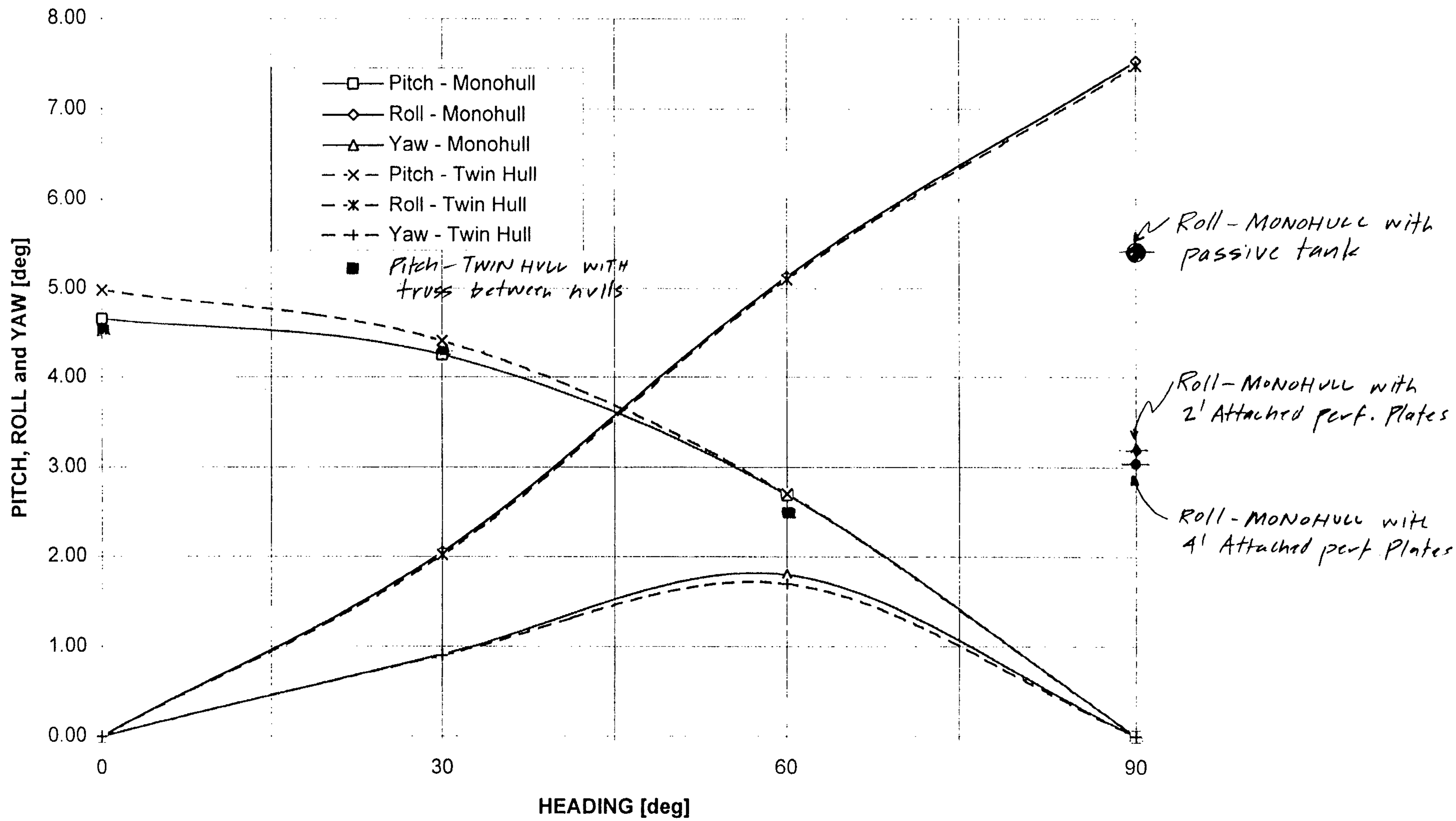
The diskette is organized into subdirectories each containing files for one of the models. The directory names as they relate to the models analyzed are:

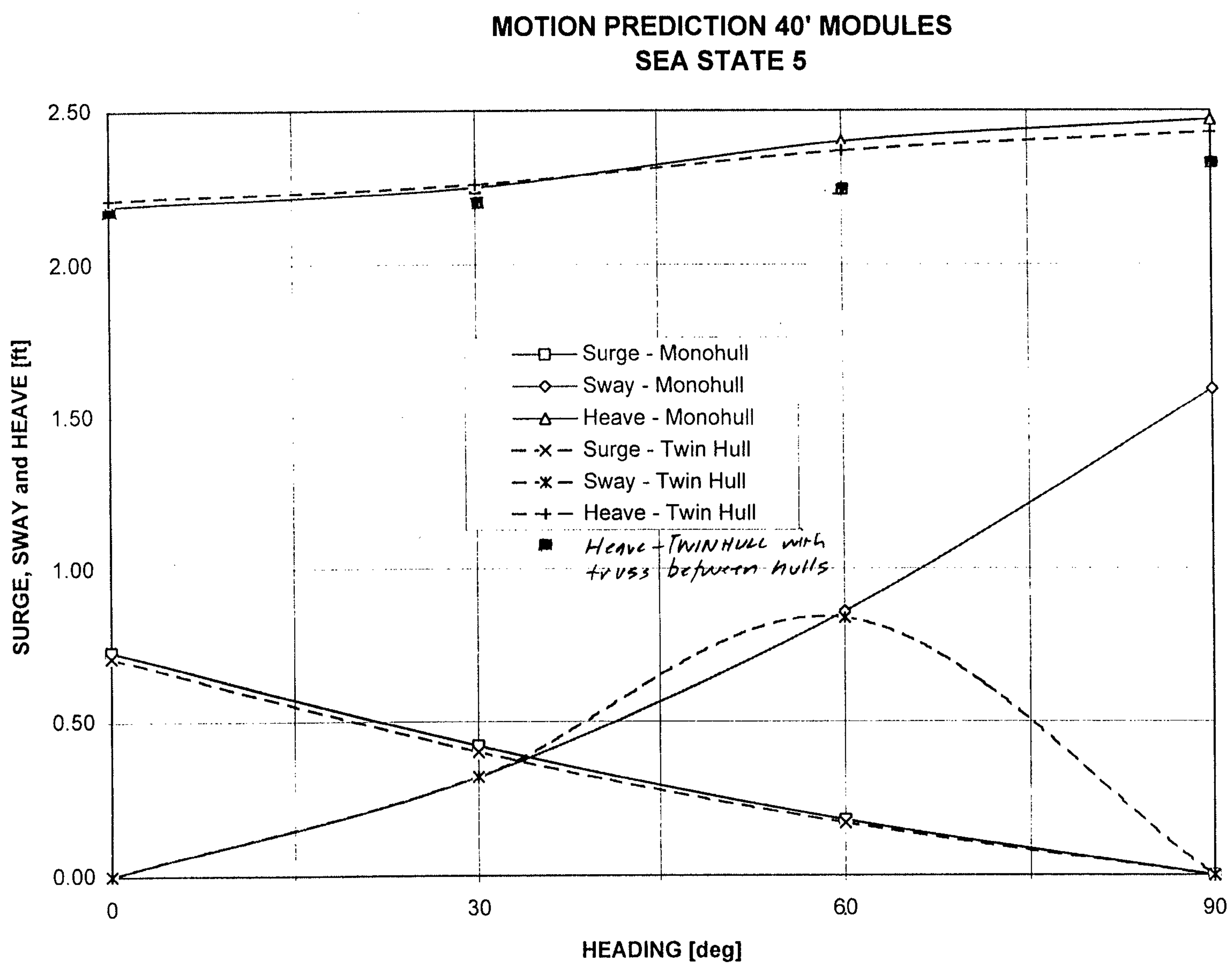
• MONO_S	40 foot monohull
• MONO_M	80 foot monohull
• MONO_L	120 foot monohull
• MONO_SH	40 foot monohull with at displacement with heeling tank included
• TWIN_S	40 foot catamaran
• TWIN_M	80 foot catamaran
• TWIN_L	120 foot catamaran
• DOUBLE_L	2 - 120 foot units connected side-to-side
• GARISON	Benchmark against Garrison results

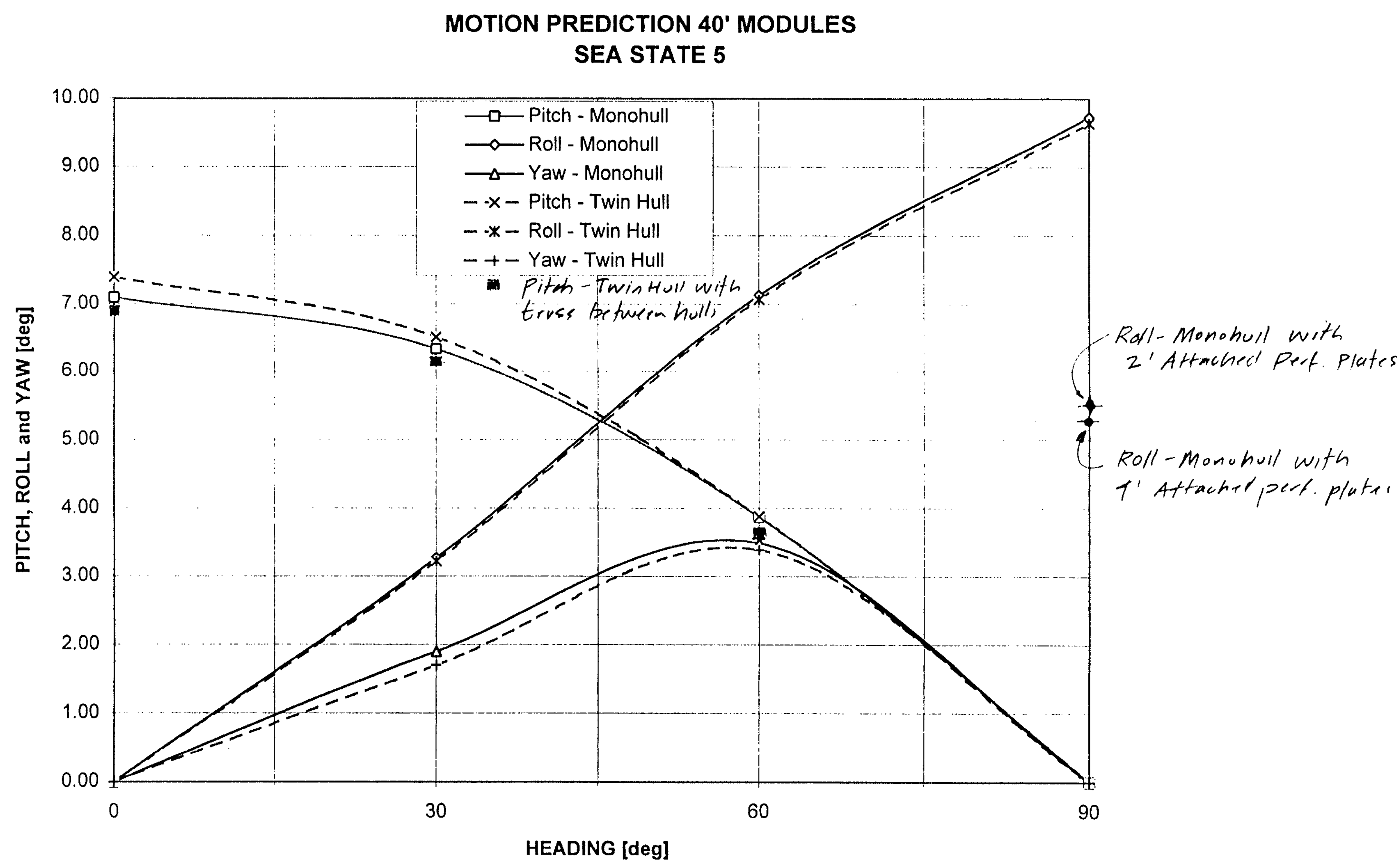
Each subdirectory contains three files: *.dat which contains an ASCII input file; *.plt which contains a model plot file (may require an AQWA utility to generate hard copy); and *.zip which contains a compressed copy of the full output listing file. The root directory of the diskette contains a copy of the unzip utility.

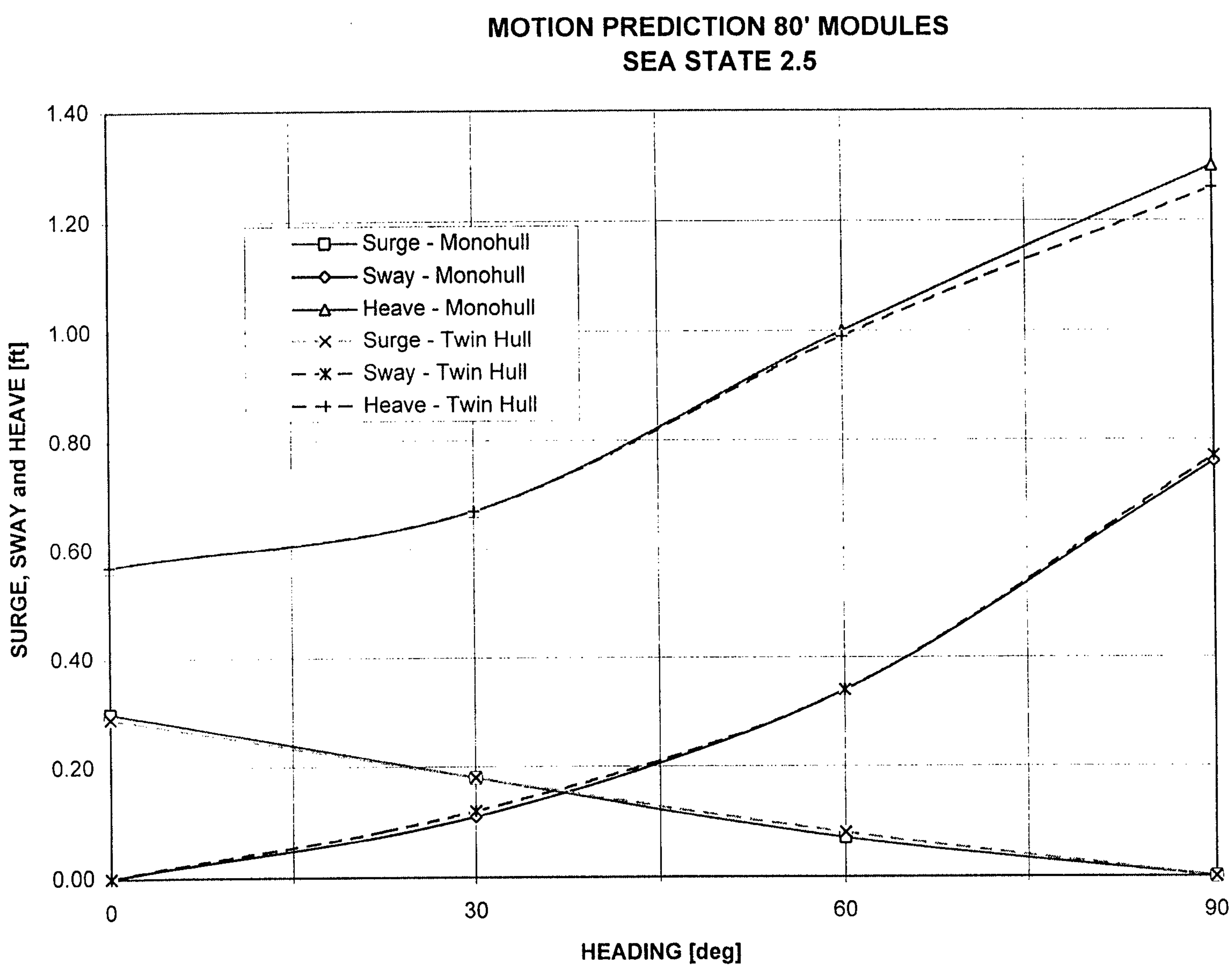

MOTION PREDICTION 40' MODULES
SEA STATE 2.5
SURGE, SWAY and HEAVE [ft]
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
30
60
90
HEADING [deg]
Surge - Monohull
Sway - Monohull
Heave - Monohull
Surge - Twin Hull
Sway Twin Hull
Heave -Twin Hull
Heave - Twin Hull with truss between hulls

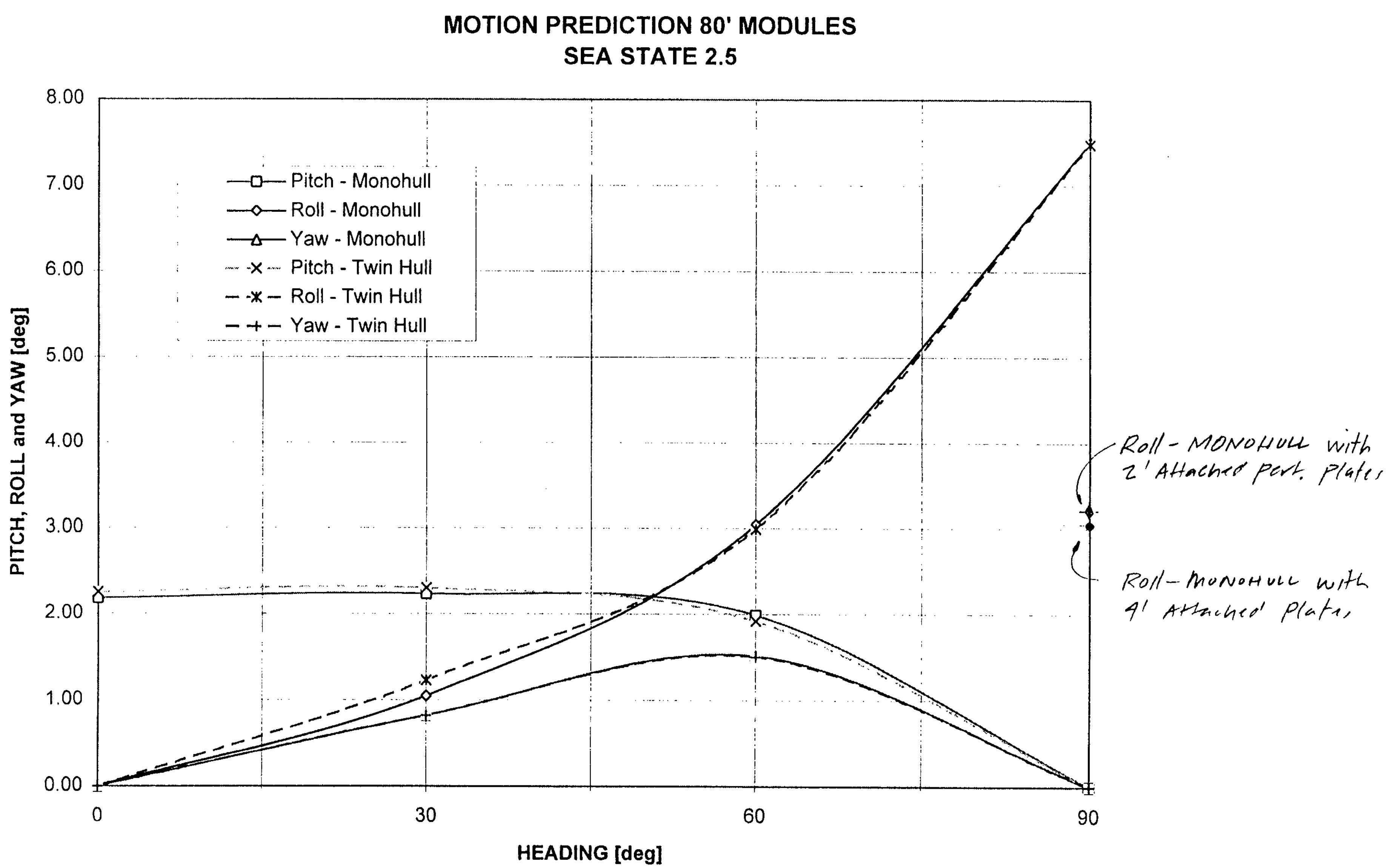
MOTION PREDICTION 40' MODULES
SEA STATE 2.5



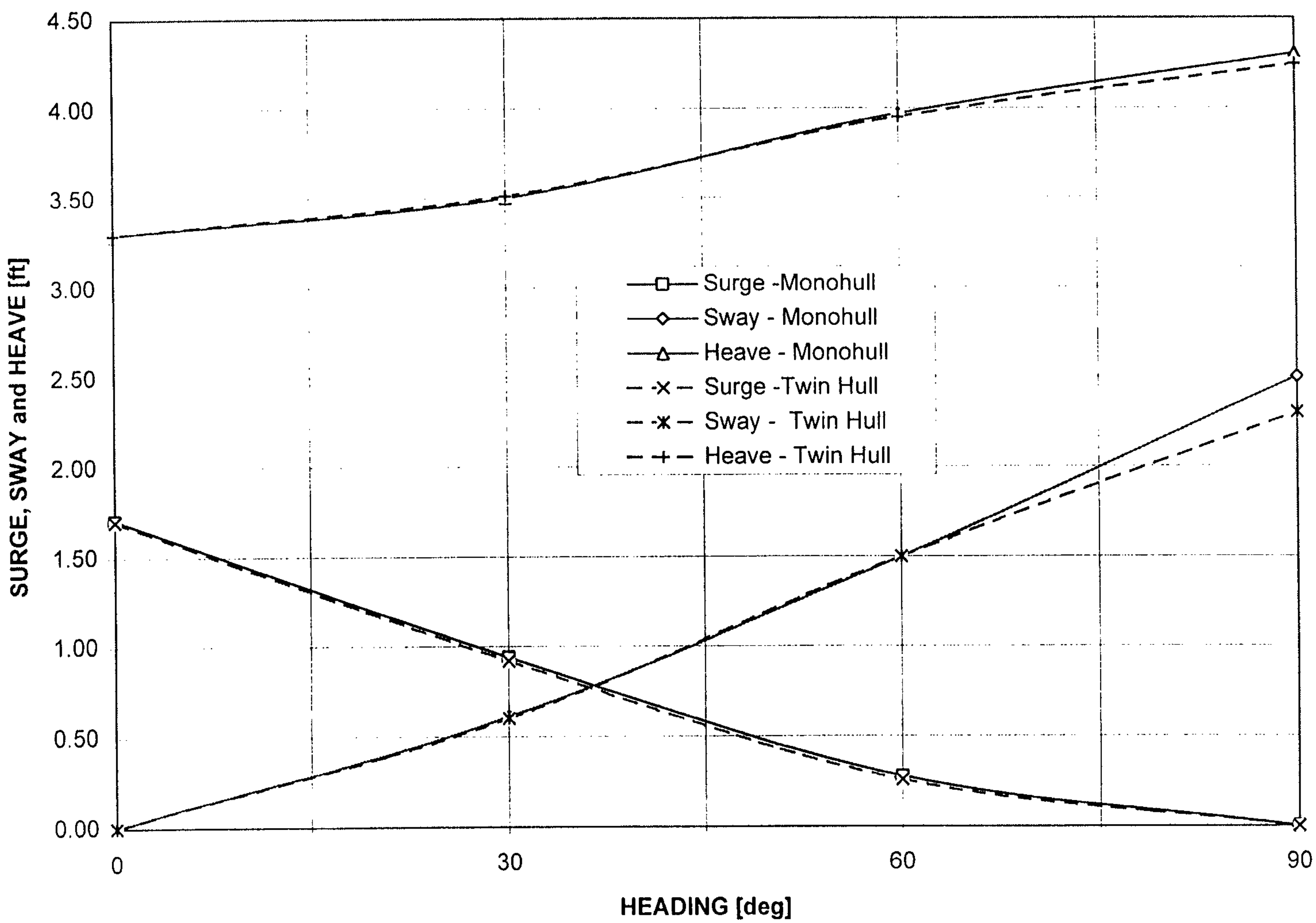

MOTION PREDICTION 40' MODULES
SEA STATE 5
2.50
2.00
1.50
1.00
0.50
0.00
SURGE, SWAY and HEAVE [ft]
0
30
60
90
HEADING [deg]
Surge - Monohull
Sway - Monohull
Heave - Monohull
Surge - Twin Hull
Sway - Twin Hull
Heave - Twin Hull
Heave - TWIN HULL with truss between hulls

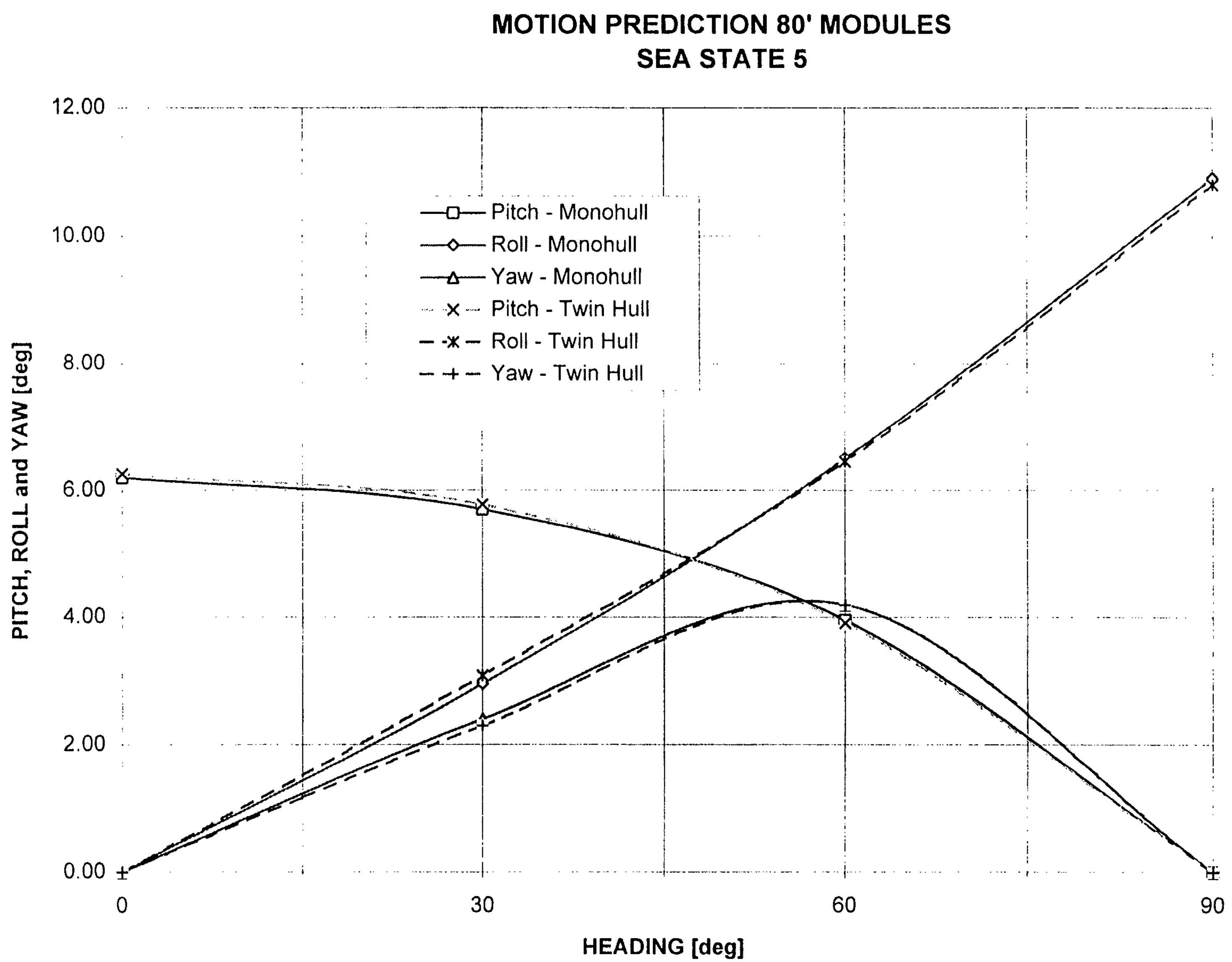

MOTION PREDICTION 40' MODULES
SEA STATE 5
PITCH, ROLL and YAW [deg]
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
30
60
90
HEADING [deg]
Pitch - Monohull
Roll - Monohull
Yaw - Monohull
Pitch - Twin Hull
Roll - Twin Hull
Yaw - Twin Hull
Pitch - Twin Hull with truss between hulls
Roll - Monohull with 2' Attached Perf. Plates
Roll - Monohull with 1' Attached perf. plates

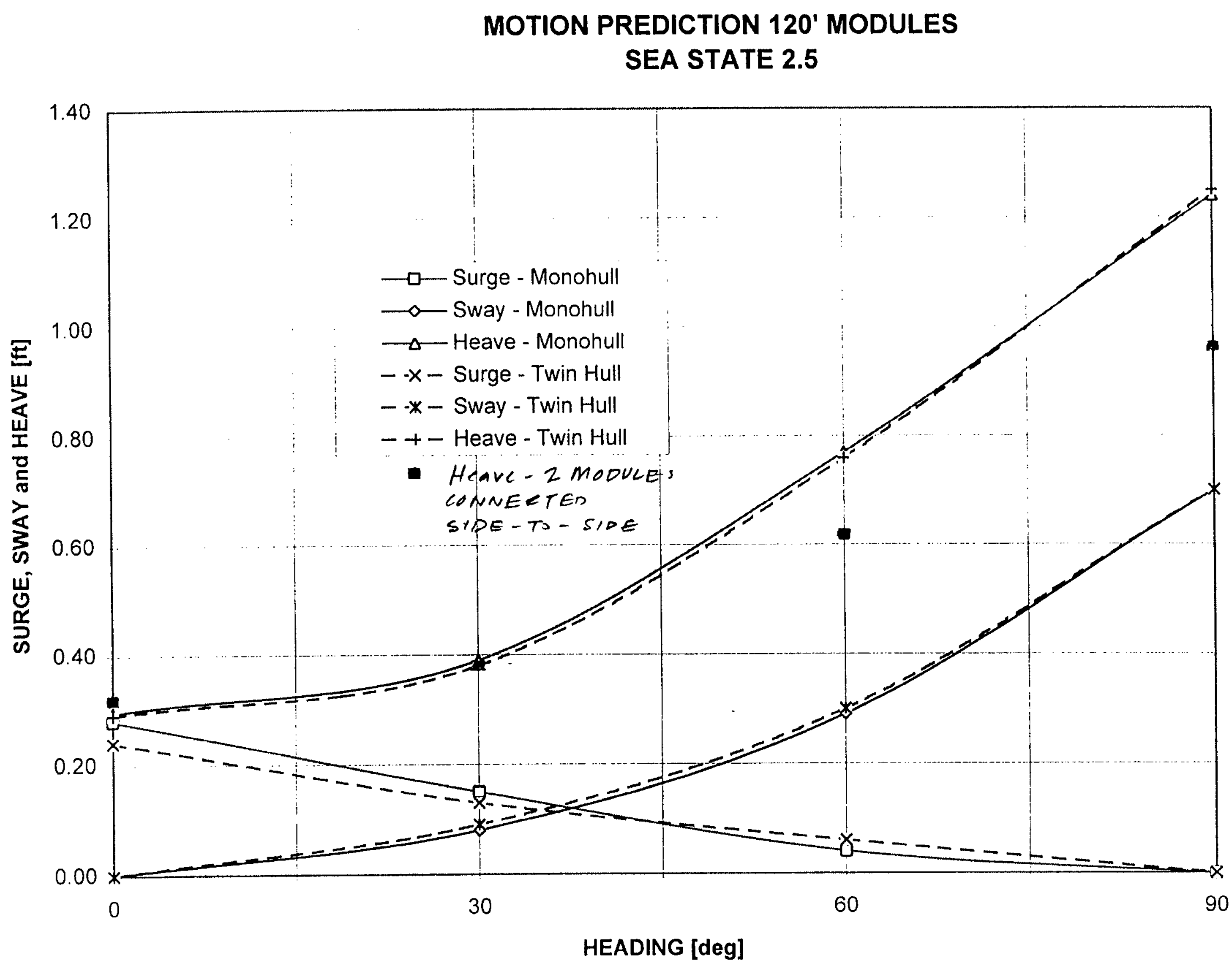

MOTION PREDICTION 80' MODULES
SEA STATE 2.5
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
SURGE, SWAY and HEAVE [ft]
0
30
60
90
HEADING [deg]
Surge - Monohull
Sway - Monohull
Heave - Monohull
Surge - Twin Hull
Sway - Twin Hull
Heave - Twin Hull


MOTION PREDICTION 80' MODULES
SEA STATE 2.5
PITCH, ROLL and YAW [deg]
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
30
60
90
HEADING [deg]
Pitch - Monohull
Roll - Monohull
Yaw - Monohull
Pitch - Twin Hull
Roll - Twin Hull
Yaw - Twin Hull
Roll - MONOHULL with 2' Attached perf. plates
Roll - MONOHULL with 4' Attached plates

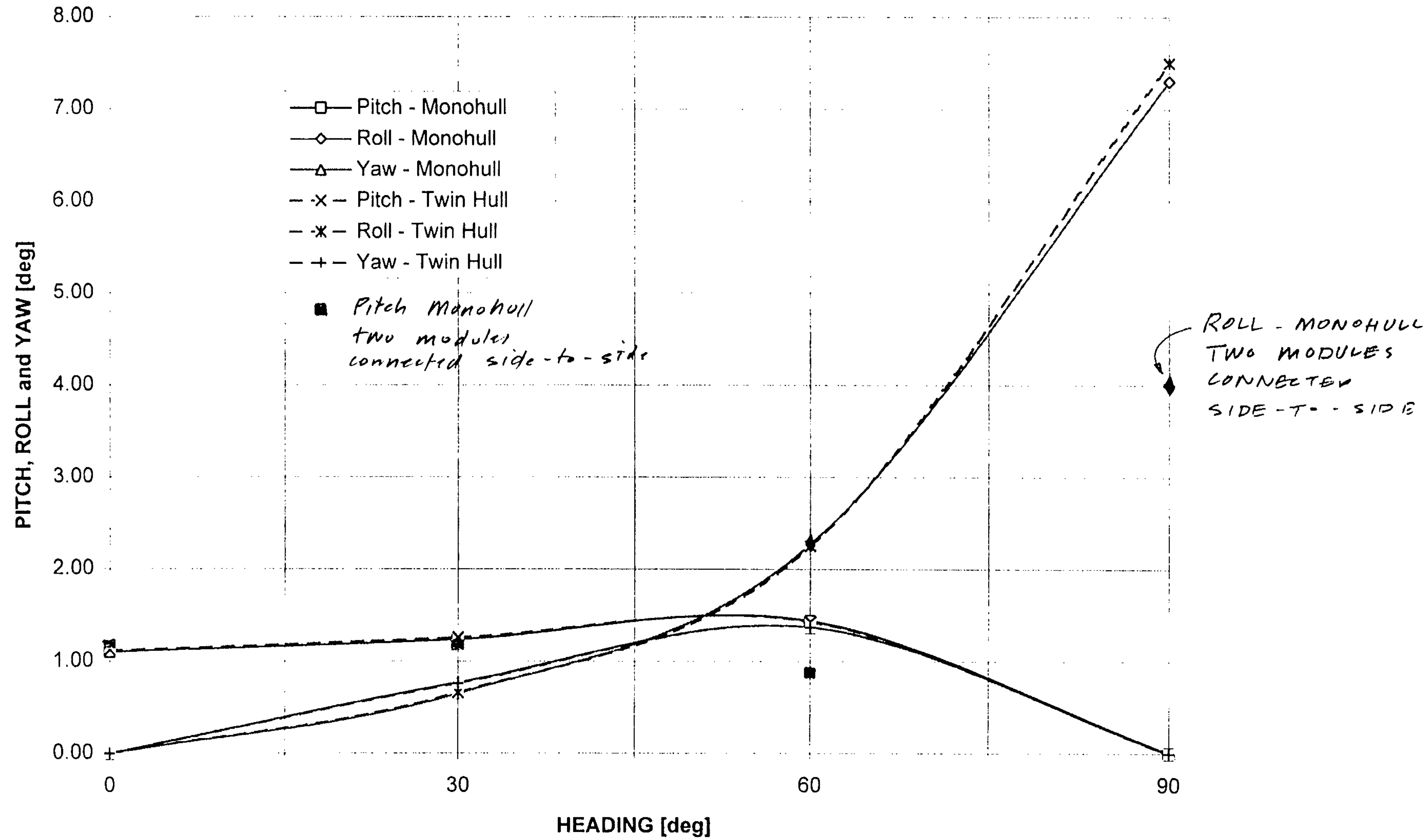
MOTION PREDICTION 80' MODULES
SEA STATE 5



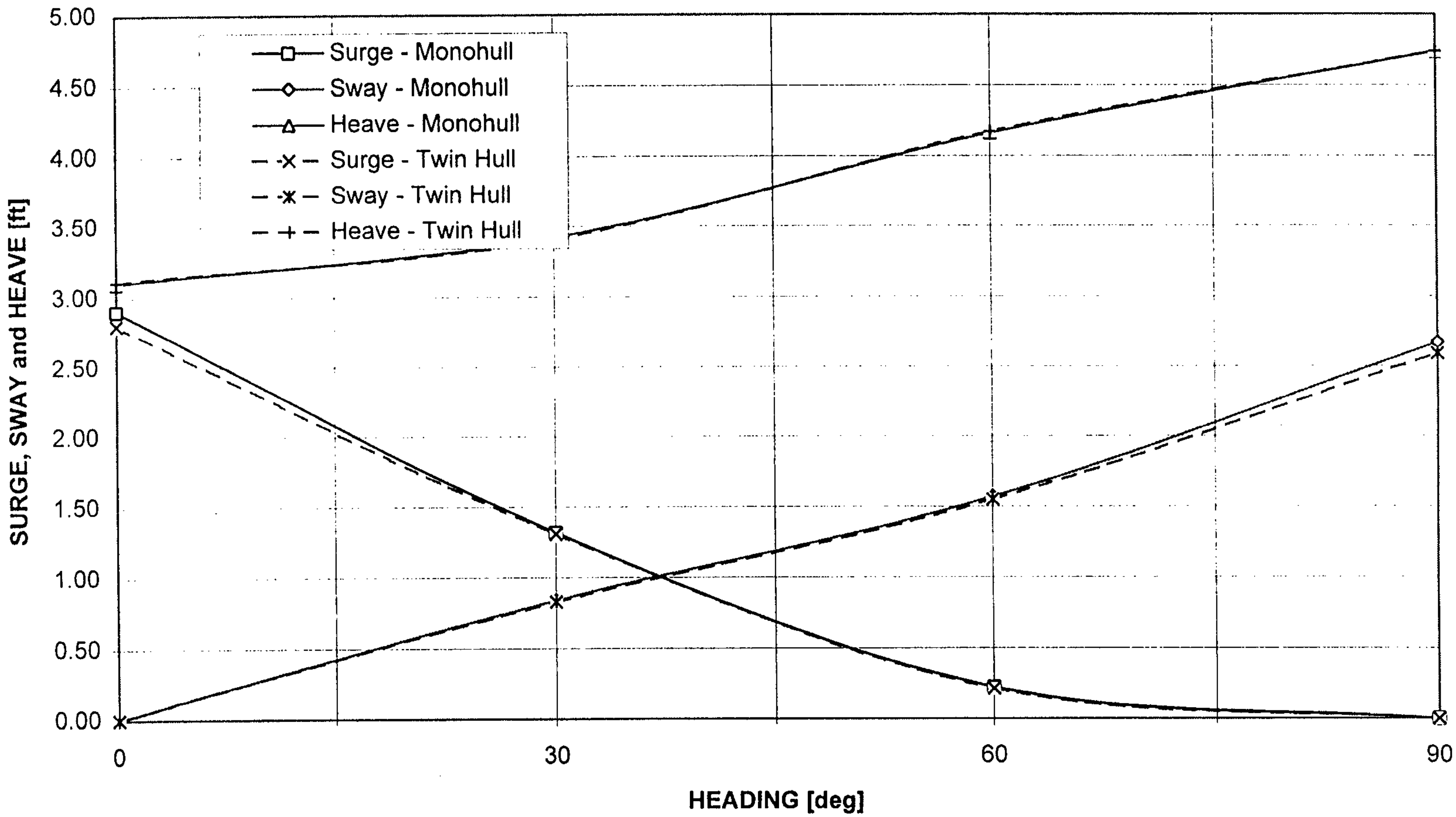

MOTION PREDICTION 80' MODULES
SEA STATE 5
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
30
60
90
PITCH, ROLL and YAW [deg]
HEADING [deg]
Pitch - Monohull
Roll - Monohull
Yaw - Monohull
Pitch - Twin Hull
Roll - Twin Hull
Yaw - Twin Hull

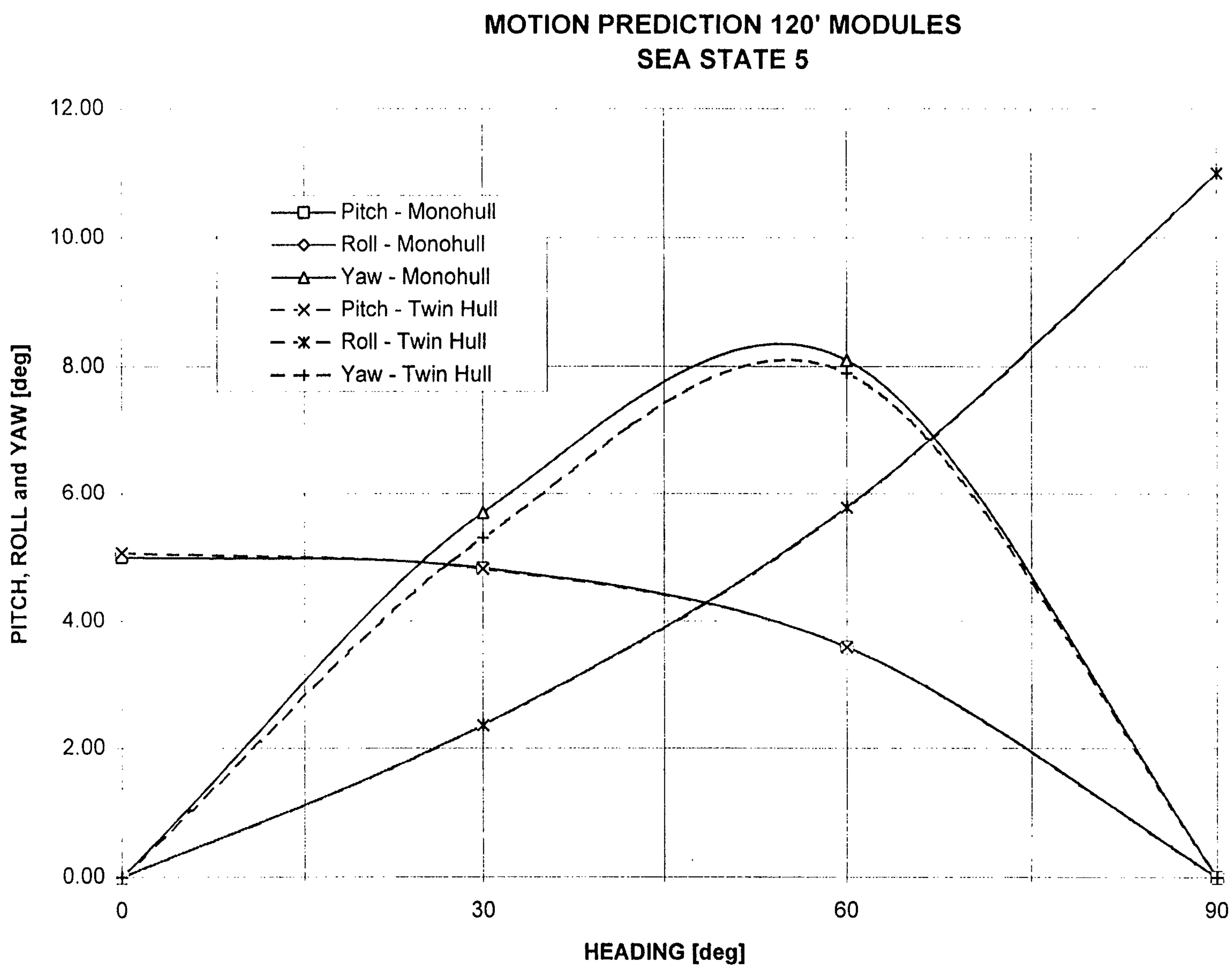

MOTION PREDICTION 120' MODULES
SEA STATE 2.5
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
30
60
90
SURGE, SWAY and HEAVE [ft]
HEADING [deg]
Surge - Monohull
Sway - Monohull
Heave - Monohull
Surge - Twin Hull
Sway - Twin Hull
Heave - Twin Hull
Heave - 2 MODULES CONNECTED SIDE - TO - SIDE

MOTION PREDICTION 120' MODULES
SEA STATE 2.5



MOTION PREDICTION 120' MODULES
SEA STATE 5




MOTION PREDICTION 120' MODULES
SEA STATE 5
Pitch - Monohull
Roll - Monohull
Yaw - Monohull
Pitch - Twin Hull
Roll - Twin Hull
Yaw - Twin Hull
PITCH, ROLL and YAW [deg]
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0
30
60
90
HEADING [deg]

Example Spectral Response Calculations 1/5

HEAVE MOTIONS IN HEAD SEAS, MONOHULL 40 FT MODULE

Irregular Wave Significant Height: 3.000 (ft)
Irregular Wave Modal Frequency: 1.2570 (rad/s)

Wave Frequency (rad/s)	Heave Amplitude Response	Wave Spectrum	Heave Response Spectrum
0.9670	0.9385	0.2337	0.2058
1.0470	0.9204	0.4151	0.3517
1.1420	0.8931	0.5762	0.4596
1.2570	0.8497	0.6400	0.4621
1.3960	0.7779	0.5814	0.3518
1.5710	0.6572	0.4389	0.1896
1.7950	0.4701	0.2785	0.0616
2.0940	0.2702	0.1480	0.0108
2.2480	0.2248	0.1081	0.0055
2.5130	0.1925	0.0647	0.0024
2.9020	0.1132	0.0326	0.0004
3.1420	0.0739	0.0222	0.0001

Integral of Response Spectrum, m_o 0.2596
Significant Amplitude Response, $2\sqrt{m_o}$ 1.02 (ft)

Irregular Wave Significant Height: 3.3 (ft)
Irregular Wave Modal Frequency: 1.131(rad/s)

Wave Frequency (rad/s)	Heave Amplitude Response	Wave Spectrum	Heave Response Spectrum
0.9670	0.9385	0.6339	0.5583
1.0470	0.9204	0.8056	0.6824
1.1420	0.8931	0.8599	0.6859
1.2570	0.8497	0.7808	0.5638
1.3960	0.7779	0.6120	0.3703
1.5710	0.6572	0.4153	0.1794
1.7950	0.4701	0.2450	0.0541
2.0940	0.2702	0.1242	0.0091
2.2480	0.2248	0.0894	0.0045
2.5130	0.1925	0.0527	0.0020
2.9020	0.1132	0.0262	0.0003
3.1420	0.0739	0.0178	0.0001

Integral of Response Spectrum, m_o 0.33749
Significant Amplitude Response, $2\sqrt{m_o}$ 1.16 (ft)

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PITCH MOTIONS IN HEAD SEAS, MONOHULL 40 FT MODULE

Irregular Wave Significant Height: 3.300 (ft)
Irregular Wave Modal Frequency: 1.1310 (rad/sec)

Wave Frequency (rad/s)	Pitch Amplitude Response	Wave Spectrum	Pitch Response Spectrum
0.9670	1.7634	0.6339	1.9712
1.0470	1.9906	0.8056	3.1921
1.1420	2.2811	0.8599	4.4744
1.2570	2.6556	0.7808	5.5066
1.3960	3.1332	0.6120	6.0075
1.5710	3.7121	0.4153	5.7222
1.7950	4.3110	0.2450	4.5531
2.0940	4.1417	0.1242	2.1296
2.2480	3.3708	0.0894	1.0156
2.5130	1.9016	0.0527	0.1906
2.9020	1.0871	0.0262	0.0310
3.1420	0.7574	0.0178	0.0102

Integral of Response Spectrum, m_o 5.57113
Significant Amplitude Response, $2\sqrt{m_o}$ 4.72 (deg)

Irregular Wave Significant Height: 3.000 (ft)
Irregular Wave Modal Frequency: 1.2570 (rad/s)

Wave Frequency (rad/s)	Pitch Amplitude Response	Wave Spectrum	Pitch Response Spectrum
0.9670	1.7634	0.2337	0.7266
1.0470	1.9906	0.4151	1.6449
1.1420	2.2811	0.5762	2.9982
1.2570	2.6556	0.6400	4.5136
1.3960	3.1332	0.5814	5.7073
1.5710	3.7121	0.4389	6.0478
1.7950	4.3110	0.2785	5.1763
2.0940	4.1417	0.1480	2.5393
2.2480	3.3708	0.1081	1.2279
2.5130	1.9016	0.0647	0.2339
2.9020	1.0871	0.0326	0.0385
3.1420	0.7574	0.0222	0.0127

Integral of Response Spectrum, m_o 5.43974
Significant Amplitude Response, $2\sqrt{m_o}$ 4.66 (deg)

3/5

SURGE MOTIONS IN HEAD SEAS, MONOHULL 40 FT MODULE

Irregular Wave Significant Height: 3.000 (ft)
Irregular Wave Modal Frequency: 1.2570 (rad/s)

Wave Frequency (rad/s)	Surge Amplitude Response	Wave Spectrum	Surge Response Spectrum
0.9670	0.9922	0.2337	0.2300
1.0470	0.9393	0.4151	0.3662
1.1420	0.8826	0.5762	0.4488
1.2570	0.8165	0.6400	0.4267
1.3960	0.7286	0.5814	0.3086
1.5710	0.5973	0.4389	0.1566
1.7950	0.3898	0.2785	0.0423
2.0940	0.0798	0.1480	0.0009
2.2480	0.0690	0.1081	0.0005
2.5130	0.1488	0.0647	0.0014
2.9020	0.1340	0.0326	0.0006
3.1420	0.1235	0.0222	0.0003

Integral of Response Spectrum, m_o 0.2343
Significant Amplitude Response, $2\sqrt{m_o}$ 0.97 (ft)

Irregular Wave Significant Height: 3.300 (ft)
Irregular Wave Modal Frequency: 1.1310 (rad/s)

Wave Frequency (rad/s)	Surge Amplitude Response	Wave Spectrum	Surge Response Spectrum
0.9670	0.9922	0.6339	0.6241
1.0470	0.9393	0.8056	0.7107
1.1420	0.8826	0.8599	0.6699
1.2570	0.8165	0.7808	0.5206
1.3960	0.7286	0.6120	0.3249
1.5710	0.5973	0.4153	0.1482
1.7950	0.3898	0.2450	0.0372
2.0940	0.0798	0.1242	0.0008
2.2480	0.0690	0.0894	0.0004
2.5130	0.1488	0.0527	0.0012
2.9020	0.1340	0.0262	0.0005
3.1420	0.1235	0.0178	0.0003

Integral of Response Spectrum, m_o 0.3147
Significant Amplitude Response, $2\sqrt{m_o}$ 1.12 (ft)

4/2

ROLL MOTIONS IN BEAM SEAS, MONOHULL 40 FT MODULE

Irregular Wave Significant Height: 3.300
Irregular Wave Modal Frequency: 1.1310 (rad/s)

Wave Frequency (rad/s)	Roll Amplitude Response	Wave Spectrum	Roll Response Spectrum
0.9670	1.8205	0.6339	2.1009
1.0470	2.0737	0.8056	3.4642
1.1420	2.4083	0.8599	4.9874
1.2570	2.8636	0.7808	6.4030
1.3960	3.5008	0.6120	7.4999
1.5710	4.4285	0.4153	8.1440
1.7950	5.9517	0.2450	8.6782
2.0940	9.0994	0.1242	10.2796
2.2480	11.1030	0.0894	11.0192
2.5130	9.4094	0.0527	4.6658
2.9020	3.3947	0.0262	0.3024
3.1420	1.9302	0.0178	0.0662

Integral of Response Spectrum, m_o 13.06
Significant Amplitude Response, $2\sqrt{m_o}$ 7.23 (deg)

Irregular Wave Significant Height: 3.000
Irregular Wave Modal Frequency: 1.2570 (rad/s)

Wave Frequency (r/sec)	Roll Amplitude Response	Wave Spectrum	Roll Response Spectrum
0.9670	1.8205	0.2337	0.7745
1.0470	2.0737	0.4151	1.7851
1.1420	2.4083	0.5762	3.3419
1.2570	2.8636	0.6400	5.2483
1.3960	3.5008	0.5814	7.1251
1.5710	4.4285	0.4389	8.6074
1.7950	5.9517	0.2785	9.8662
2.0940	9.0994	0.1480	12.2572
2.2480	11.1030	0.1081	13.3219
2.5130	9.4094	0.0647	5.7269
2.9020	3.3947	0.0326	0.3756
3.1420	1.9302	0.0222	0.0826

Integral of Response Spectrum, m_o 14.18
Significant Amplitude Response, $2\sqrt{m_o}$ 7.53 (deg)

5/5

HEAVE MOTIONS IN BEAM SEAS, MONOHULL 40 FT MODULE

Irregular Wave Significant Height: 3.000 (ft)
Irregular Wave Modal Frequency: 1.2570 (rad/s)

Wave Frequency (rad/s)	Heave Amplitude Response	Wave Spectrum	Heave Response Spectrum
0.9670	0.9806	0.2337	0.2247
1.0470	0.9752	0.4151	0.3948
1.1420	0.9675	0.5762	0.5393
1.2570	0.9559	0.6400	0.5848
1.3960	0.9379	0.5814	0.5114
1.5710	0.9067	0.4389	0.3608
1.7950	0.8422	0.2785	0.1976
2.0940	0.6823	0.1480	0.0689
2.2480	0.5710	0.1081	0.0352
2.5130	0.3870	0.0647	0.0097
2.9020	0.2150	0.0326	0.0015
3.1420	0.1549	0.0222	0.0005

Integral of Response Spectrum, m_o 0.4050
Significant Amplitude Response, $2\sqrt{m_o}$ 1.27 (ft)

Irregular Wave Significant Height: 3.300 (ft)
Irregular Wave Modal Frequency: 1.1310 (rad/s)

Wave Frequency (r/sec)	Heave Amplitude Response	Wave Spectrum	Heave Response Spectrum
0.9670	0.9806	0.6339	0.6096
1.0470	0.9752	0.8056	0.7661
1.1420	0.9675	0.8599	0.8049
1.2570	0.9559	0.7808	0.7135
1.3960	0.9379	0.6120	0.5383
1.5710	0.9067	0.4153	0.3414
1.7950	0.8422	0.2450	0.1738
2.0940	0.6823	0.1242	0.0578
2.2480	0.5710	0.0894	0.0291
2.5130	0.3870	0.0527	0.0079
2.9020	0.2150	0.0262	0.0012
3.1420	0.1549	0.0178	0.0004

Integral of Response Spectrum, m_o 0.4868
Significant Amplitude Response, $2\sqrt{m_o}$ 1.39 (ft)

Spectral Response Calculations for Truss Effects 1/4

Linear Roll RAO's

For Wave Direction #1 @ 0.00 deg

Wave Frequency (rad/s)	Roll Amplitude	Roll Phase (deg)	Irregular Wave Amp (ft)	Roll Response Spectrum
0.967	0.0000	179.83	0.2280	0.00000
1.047	0.0000	2.72	0.4088	0.00000
1.142	0.0000	-5.87	0.5716	0.00000
1.257	0.0000	179.01	0.6385	0.00000
1.396	0.0000	3.67	0.5823	0.00000
1.571	0.0000	9.77	0.4409	0.00000
1.795	0.0000	22.51	0.2804	0.00000
2.094	0.0000	30.01	0.1492	0.00000
2.248	0.0000	87.01	0.1090	0.00000
2.513	0.0000	108.28	0.0653	0.00000
2.902	0.0000	160.81	0.0329	0.00000
3.142	0.0000	-0.43	0.0224	0.00000

Significant Roll Amplitude Response $(2\sqrt{m0})$ 0.00000

For Wave Direction #2 @ 30.00 deg

Wave Frequency (rad/s)	Roll Amplitude	Roll Phase (deg)	Irregular Wave Amp (ft)	Roll Response Spectrum
0.967	0.9355	90.44	0.2280	0.19954
1.047	1.0552	90.63	0.4088	0.45520
1.142	1.2103	90.97	0.5716	0.83730
1.257	1.4055	91.56	0.6385	1.26123
1.396	1.6341	92.55	0.5823	1.55499
1.571	1.8538	94.17	0.4409	1.51524
1.795	1.8891	96.08	0.2804	1.00058
2.094	1.2898	92.39	0.1492	0.24825
2.248	0.7917	70.11	0.1090	0.06831
2.513	1.1541	12.26	0.0653	0.08691
2.902	0.8641	-12.62	0.0329	0.02456
3.142	0.5809	-45.73	0.0224	0.00755

Significant Roll Amplitude Response $(2\sqrt{m0})$ 2.20143

For Wave Direction #3 @ 60.00 deg

Wave Frequency (rad/s)	Roll Amplitude	Roll Phase (deg)	Irregular Wave Amp (ft)	Roll Response Spectrum
0.967	1.6617	90.44	0.2280	0.62952
1.047	1.8945	90.63	0.4088	1.46711
1.142	2.1998	90.96	0.5716	2.76591
1.257	2.6088	91.53	0.6385	4.34536
1.396	3.1489	92.46	0.5823	5.77415
1.571	3.8449	93.97	0.4409	6.51825
1.795	4.6707	96.02	0.2804	6.11663
2.094	5.5813	100.31	0.1492	4.64830
2.248	5.8840	107.20	0.1090	3.77276
2.513	4.4083	129.57	0.0653	1.26808
2.902	1.2038	115.85	0.0329	0.04766
3.142	0.5642	83.34	0.0224	0.00712

Significant Roll Amplitude Response ($2\sqrt{m0}$) 5.32015

For Wave Direction #4 @ 90.00 deg

Wave Frequency (rad/s)	Roll Amplitude	Roll Phase (deg)	Irregular Wave Amp (ft)	Roll Response Spectrum
0.967	1.9453	90.43	0.2280	0.86271
1.047	2.2240	90.62	0.4088	2.02201
1.142	2.6003	90.95	0.5716	3.86472
1.257	3.1158	91.51	0.6385	6.19846
1.396	3.8322	92.42	0.5823	8.55192
1.571	4.8061	93.88	0.4409	10.18476
1.795	6.2969	95.94	0.2804	11.11756
2.094	8.7580	101.64	0.1492	11.44574
2.248	10.4124	110.86	0.1090	11.81456
2.513	9.7939	141.42	0.0653	6.25915
2.902	3.6413	149.77	0.0329	0.43612
3.142	1.9931	130.73	0.0224	0.08889

Significant Roll Amplitude Response ($2\sqrt{m0}$) 7.73262

3/4

NonLinear Roll RAO's

For Wave Direction #1 @ 0.00 deg

Wave Frequency (rad/s)	Roll Amplitude	Roll Phase (deg)	Irregular Wave Amp (ft)	Roll Response Spectrum
0.967	0.0000	179.83	0.2280	0.00000
1.047	0.0000	2.72	0.4088	0.00000
1.142	0.0000	-5.87	0.5716	0.00000
1.257	0.0000	179.01	0.6385	0.00000
1.396	0.0000	3.67	0.5823	0.00000
1.571	0.0000	9.77	0.4409	0.00000
1.795	0.0000	22.51	0.2804	0.00000
2.094	0.0000	30.01	0.1492	0.00000
2.248	0.0000	87.01	0.1090	0.00000
2.513	0.0000	108.28	0.0653	0.00000
2.902	0.0000	160.81	0.0329	0.00000
3.142	0.0000	-0.43	0.0224	0.00000

Significant Roll Amplitude Response ($2\sqrt{m0}$) 0.00000

For Wave Direction #2 @ 30.00 deg

Wave Frequency (rad/s)	Roll Amplitude	Roll Phase (deg)	Irregular Wave Amp (ft)	Roll Response Spectrum
0.967	0.9354	90.93	0.2280	0.19950
1.047	1.0550	91.26	0.4088	0.45503
1.142	1.2098	91.81	0.5716	0.83662
1.257	1.4041	92.72	0.6385	1.25869
1.396	1.6296	94.24	0.5823	1.54643
1.571	1.8388	96.67	0.4409	1.49087
1.795	1.8468	99.55	0.2804	0.95627
2.094	1.2301	95.49	0.1492	0.22581
2.248	0.7530	71.82	0.1090	0.06180
2.513	1.0545	10.62	0.0653	0.07256
2.902	0.8468	-14.84	0.0329	0.02359
3.142	0.5772	-46.91	0.0224	0.00746

Significant Roll Amplitude Response ($2\sqrt{m0}$) 2.17431

4/2

For Wave Direction #3 @ 60.00 deg

Wave Frequency (rad/s)	Roll Amplitude	Roll Phase (deg)	Irregular Wave Amp (ft)	Roll Response Spectrum
0.967	1.6613	91.32	0.2280	0.62924
1.047	1.8937	91.76	0.4088	1.46589
1.142	2.1978	92.48	0.5716	2.76096
1.257	2.6031	93.68	0.6385	4.32635
1.396	3.1299	95.69	0.5823	5.70469
1.571	3.7741	99.05	0.4409	6.28053
1.795	4.4044	104.01	0.2804	5.43903
2.094	4.6607	110.66	0.1492	3.24147
2.248	4.4725	115.33	0.1090	2.17979
2.513	3.3784	125.15	0.0653	0.74480
2.902	1.1703	112.81	0.0329	0.04505
3.142	0.5607	82.19	0.0224	0.00704

Significant Roll Amplitude Response $(2\sqrt{m0})$ 4.90433

For Wave Direction #4 @ 90.00 deg

Wave Frequency (rad/s)	Roll Amplitude	Roll Phase (deg)	Irregular Wave Amp (ft)	Roll Response Spectrum
0.967	1.9447	91.46	0.2280	0.86223
1.047	2.2229	91.95	0.4088	2.01987
1.142	2.5973	92.75	0.5716	3.85597
1.257	3.1072	94.08	0.6385	6.16409
1.396	3.8025	96.33	0.5823	8.42026
1.571	4.6912	100.16	0.4409	9.70372
1.795	5.8102	106.27	0.2804	9.46545
2.094	6.7568	115.57	0.1492	6.81266
2.248	6.9505	121.99	0.1090	5.26446
2.513	6.2477	134.61	0.0653	2.54708
2.902	3.3442	141.53	0.0329	0.36787
3.142	1.9480	126.78	0.0224	0.08491

Significant Roll Amplitude Response $(2\sqrt{m0})$ 6.55341

Spectral Response [illegible] for [illegible]

2

MONOHULL ROLL MOTIONS IN BEAM SEAS (UNSTABILIZED)

Irregular Wave Significant Height: 3.000 (ft)
Irregular Wave Modal Frequency: 1.2570 (rad/s)

Wave Frequency (rad/s)	Amplitude Response (Unstabilized)	Wave Spectrum	Response Spectrum
0.9670	1.8224	0.2337	0.7761
1.0470	2.0777	0.4151	1.7920
1.1420	2.4164	0.5762	3.3644
1.2570	2.8804	0.6400	5.3101
1.3960	3.5374	0.5814	7.2748
1.5710	4.5172	0.4389	8.9556
1.7950	6.2072	0.2785	10.7314
2.0940	10.0186	0.1480	14.8586
2.2480	12.1099	0.1081	15.8478
2.5130	8.1158	0.0647	4.2604
2.9020	2.7244	0.0326	0.2419
3.1420	1.5378	0.0222	0.0524

Integral of Response Spectrum, m_o 15.11
Significant Amplitude Response, $2\sqrt{m_o}$ 7.78 (deg)

Irregular Wave Significant Height: 3.300 (ft)
Irregular Wave Modal Frequency: 1.1310 (rad/s)

Wave Frequency (rad/s)	Amplitude Response (Unstabilized)	Wave Spectrum	Response Spectrum
0.9670	1.8224	0.6339	2.1053
1.0470	2.0777	0.8056	3.4775
1.1420	2.4164	0.8599	5.0210
1.2570	2.8804	0.7808	6.4783
1.3960	3.5374	0.6120	7.6575
1.5710	4.5172	0.4153	8.4735
1.7950	6.2072	0.2450	9.4393
2.0940	10.0186	0.1242	12.4613
2.2480	12.1099	0.0894	13.1084
2.5130	8.1158	0.0527	3.4710
2.9020	2.7244	0.0262	0.1948
3.1420	1.5378	0.0178	0.0420

Integral of Response Spectrum, m_o 13.87
Significant Amplitude Response, $2\sqrt{m_o}$ 7.45 (deg)

2

MONOHULL ROLL MOTIONS IN BEAM SEAS (TANK STABILIZED)

Irregular Wave Significant Height: 3.000 (ft)
Irregular Wave Modal Frequency: 1.2570 (rad/s)

Wave Frequency (rad/s)	Amplitude Response (Stabilized)	Wave Spectrum	Response Spectrum
0.9670	1.8300	0.2337	0.7826
1.0470	1.9100	0.4151	1.5144
1.1420	2.0900	0.5762	2.5169
1.2570	2.6100	0.6400	4.3599
1.3960	2.7400	0.5814	4.3647
1.5710	3.8600	0.4389	6.5393
1.7950	5.0400	0.2785	7.0750
2.0940	5.8700	0.1480	5.1008
2.2480	5.6200	0.1081	3.4132
2.5130	5.1000	0.0647	1.6824
2.9020	2.6000	0.0326	0.2203
3.1420	1.4600	0.0222	0.0473

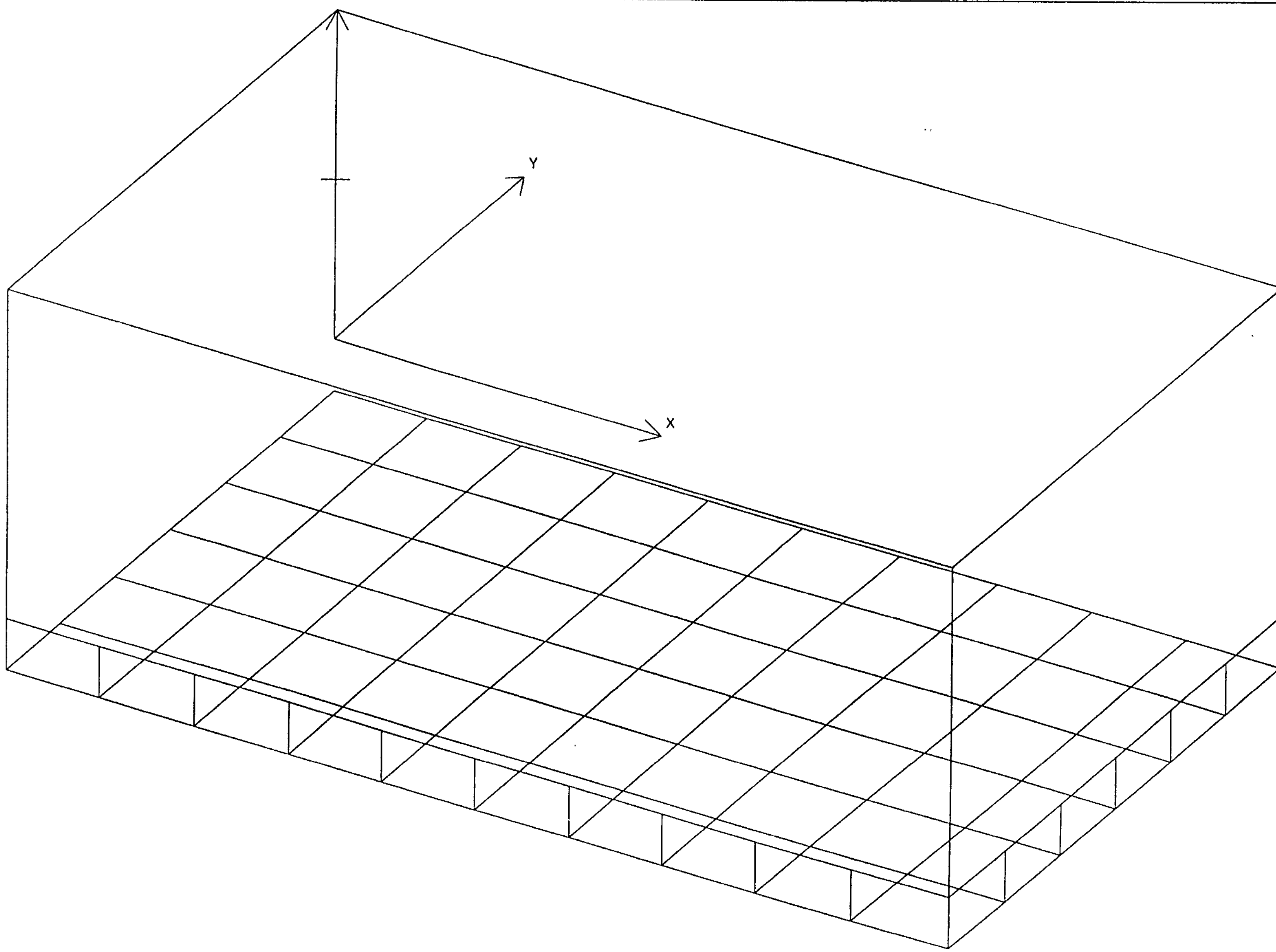
Integral of Response Spectrum, m_o 7.32
Significant Amplitude Response, $2\sqrt{m_o}$ 5.41 (deg)

Irregular Wave Significant Height: 3.300 (ft)
Irregular Wave Modal Frequency: 1.1310 (rad/s)

Wave Frequency (rad/s)	Amplitude Response (Stabilized)	Wave Spectrum	Response Spectrum
0.9670	1.8300	0.6339	2.1229
1.0470	1.9100	0.8056	2.9388
1.1420	2.0900	0.8599	3.7561
1.2570	2.6100	0.7808	5.3191
1.3960	2.7400	0.6120	4.5943
1.5710	3.8600	0.4153	6.1873
1.7950	5.0400	0.2450	6.2231
2.0940	5.8700	0.1242	4.2779
2.2480	5.6200	0.0894	2.8232
2.5130	5.1000	0.0527	1.3707
2.9020	2.6000	0.0262	0.1774
3.1420	1.4600	0.0178	0.0379

Integral of Response Spectrum, m_o 7.06
Significant Amplitude Response, $2\sqrt{m_o}$ 5.32 (deg)

Example Model Plot File



PLOT TITLE-
RUN TITLE- ACBL CONCEPT MOTION COMPARISONS: MONOHULL, 40 FEET MODULE

Example AQWA output (Reduced Format)

JOB ACBL LINE

TITLE ACBL CONCEPT MOTION COMPARISONS: MONOHULL, 40 FEET MODULE

AQWA-LINE VERSION 4.2A/R2 14-SEP-95

********* MASS AND INERTIA PROPERTIES OF STRUCTURE 1 *********

ELEMENT TYPE	NUMBER OF ELEMENTS	MASS	WEIGHT
PMAS	1	2.0870E+03	6.7201E+04
QPPL	316	0.0000E+00	0.0000E+00
T O T A L	317	2.0870E+03	6.7201E+04

	X	Y	Z
CENTRE OF GRAVITY	0.000	0.000	3.410
INERTIA MATRIX	1.437E+05	0.000E+00	0.000E+00
	0.000E+00	3.509E+05	0.000E+00
	0.000E+00	0.000E+00	4.946E+05

******SECONDARY DIFFRACTION MODELLING CHECK******

******FOR STRUCTURE 1******

DEPTH OF LOWEST POINT ON VESSEL	1.09
SEA BED CLEARENCE OF LOWEST POINT ON VESSEL .	48.91
MAX RATIO OF ELEMENT SIDE TO 1/7 WAVELENGTH .	0.59
NUMBER OF MORISON POINTS	4
NUMBER OF DIFFRACTING ELEMENTS	76
NUMBER OF DIFFRACTING ELEMENTS IGNORED . . .	0
NUMBER OF FIELD POINTS	0
NUMBER OF FIELD POINTS IGNORED	0
TOTAL NUMBER OF DIFFRACTION POINTS	76

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****HYDROSTATIC PROPERTIES IN THE FREE FLOATING POSITION****
                    ****FOR STRUCTURE 1****

          1. STIFFNESS MATRIX AT THE CENTRE OF GRAVITY
          --------------------------------------------
   C.O.G      GX=     0.000 GY=     0.000 GZ=     3.410

 HEAVE( Z) =      6.144E+04    -1.462E-02    -1.312E-02
 ROLL(RX)  =     -1.462E-02     2.684E+06     1.270E-02
 PITCH(RY) =     -1.312E-02     1.270E-02     7.927E+06

          2. HYDROSTATIC DISPLACEMENT PROPERTIES
          -------------------------------------

 ACTUAL VOLUMETRIC DISPLACEMENT . . . . . . = 1.046E+03
 EQUIVALENT VOLUME OF STRUCTURE . . . . . . = 1.050E+03

 POSITION OF THE CENTRE OF BUOYANCY      BX =      0.000
                                         BY =      0.000
                                         BZ =     -0.545

 AN INCOMPLETE ELEMENT DESCRIPTION OF    FX =      0.000
 THE HULL GIVES OUT OF BALANCE FORCES    FY =      0.000
 AND MOMENTS. IF THE C.O.B. IS NOT       FZ =     -0.003
 BELOW THE C.O.G. THIS GIVES OUT OF      MX =      0.000
 BALANCE MOMENTS (FORCES ARE DIVIDED     MY =      0.000
 BY THE WEIGHT AND ARE W.R.T. AXES       MZ =      0.000
 PARALLEL TO THE FIXED REFERENCE AXES)

          3. CUT WATER PLANE AREA PROPERTIES
          ----------------------------------

 CUT WATER PLANE AREA . . . . . . . . . . . = 9.600E+02

 CENTRE OF FLOATATION. I.E. CENTROID      X =      0.000
 POSITION IN THE FIXED REFERENCE AXES     Y =      0.000

 PRINCIPAL SECOND MOMENTS OF AREA        IXX= 4.608E+04
                                         IYY= 1.280E+05

 ANGLE THE PRINCIPAL AXES MAKE WITH      PHI=      0.000
 THE FIXED REFERENCE AXIS SYSTEM

          4. SMALL ANGLE STABILITY PARAMETERS
          -----------------------------------

 DISTANCE BETWEEN C.O.G. AND C.O.B       BG =      3.955

 METACENTRIC HEIGHTS WITH RESPECT TO     GMX=     40.082
 THE PRINCIPAL AXES OF THE CUT AREA      GMY=    118.370

 DISTANCE BETWEEN THE C.O.B. AND THE     BMX=     44.037
 METACENTRE (BMX=GMX+BG,BMY=GMY+BG)      BMY=    122.325

 RESTORING MOMENT ABOUT THE PRINCIPAL    MX = 4.685E+04
 AXES PER DEGREE ROTATION                MY = 1.384E+05
```

******NATURAL FREQUENCIES/PERIODS FOR STRUCTURE 1******

N.B. THESE NATURAL FREQUENCIES DO *NOT* INCLUDE STIFFNESS DUE TO MOORING LINES.

FREQUENCY	FREQUENCY	UNDAMPED NATURAL FREQUENCIES(RADIANS/SECOND)					
NUMBER	(RAD/S)	SURGE(X)	SWAY(Y)	HEAVE(Z)	ROLL(RX)	PITCH(RY)	YAW(RZ)
1	0.967	0.000	0.000	1.643	2.192	1.982	0.000
2	1.047	0.000	0.000	1.671	2.185	1.976	0.000
3	1.142	0.000	0.000	1.704	2.176	1.970	0.000
4	1.257	0.000	0.000	1.749	2.171	1.973	0.000
5	1.396	0.000	0.000	1.806	2.176	1.992	0.000
6	1.571	0.000	0.000	1.876	2.203	2.037	0.000
7	1.795	0.000	0.000	1.957	2.261	2.112	0.000
8	2.094	0.000	0.000	2.040	2.350	2.214	0.000
9	2.248	0.000	0.000	2.069	2.388	2.259	0.000
10	2.513	0.000	0.000	2.100	2.435	2.323	0.000
11	2.902	0.000	0.000	2.109	2.467	2.378	0.000
12	3.142	0.000	0.000	2.102	2.474	2.386	0.000

PERIOD	PERIOD	UNDAMPED NATURAL PERIOD(SECONDS)					
NUMBER	(SECONDS)	SURGE(X)	SWAY(Y)	HEAVE(Z)	ROLL(RX)	PITCH(RY)	YAW(RZ)
1	6.50	0.00	0.00	3.82	2.87	3.17	0.00
2	6.00	0.00	0.00	3.76	2.87	3.18	0.00
3	5.50	0.00	0.00	3.69	2.89	3.19	0.00
4	5.00	0.00	0.00	3.59	2.89	3.18	0.00
5	4.50	0.00	0.00	3.48	2.89	3.15	0.00
6	4.00	0.00	0.00	3.35	2.85	3.08	0.00
7	3.50	0.00	0.00	3.21	2.78	2.97	0.00
8	3.00	0.00	0.00	3.08	2.67	2.84	0.00
9	2.80	0.00	0.00	3.04	2.63	2.78	0.00
10	2.50	0.00	0.00	2.99	2.58	2.71	0.00
11	2.16	0.00	0.00	2.98	2.55	2.64	0.00
12	2.00	0.00	0.00	2.99	2.54	2.63	0.00

FREQUENCY	FREQUENCY	APPROXIMATE PERCENTAGE CRITICAL DAMPING					
NUMBER	(RAD/S)	SURGE(X)	SWAY(Y)	HEAVE(Z)	ROLL(RX)	PITCH(RY)	YAW(RZ)
1	0.967	0.0	0.0	12.7	0.6	1.4	0.0
2	1.047	0.0	0.0	14.2	0.9	2.0	0.0

**** N A T U R A L   F R E Q U E N C I E S / P E R I O D S   F O R   S T R U C T U R E   1 ****

N.B. THESE NATURAL FREQUENCIES DO *NOT* INCLUDE STIFFNESS DUE TO MOORING LINES.

FREQUENCY NUMBER	FREQUENCY (RAD/S)	APPROXIMATE PERCENTAGE CRITICAL DAMPING SURGE(X)	SWAY(Y)	HEAVE(Z)	ROLL(RX)	PITCH(RY)	YAW(RZ)
3	1.142	0.0	0.0	15.9	1.4	2.9	0.0
4	1.257	0.0	0.0	17.9	2.3	4.4	0.0
5	1.396	0.0	0.0	20.2	3.6	6.5	0.0
6	1.571	0.0	0.0	22.4	5.6	9.2	0.0
7	1.795	0.0	0.0	24.0	7.9	12.1	0.0
8	2.094	0.0	0.0	24.3	9.6	14.4	0.0
9	2.248	0.0	0.0	23.8	9.8	15.0	0.0
10	2.513	0.0	0.0	21.8	9.5	15.0	0.0
11	2.902	0.0	0.0	17.8	8.1	13.0	0.0
12	3.142	0.0	0.0	15.2	7.1	11.1	0.0

******HYDRODYNAMIC PARAMETERS FOR STRUCTURE 1******

ADDED MASS-VARIATION WITH WAVE PERIOD/FREQUENCY

PERIOD (SECS)	FREQ (RAD/S)	M 11	M 22	M 33	M 44	M 55	M 66	M 13	M 15	M 24	M 26	M 35	M 46
6.50	0.967	2.32E+02	4.02E+02	2.07E+04	4.15E+05	1.67E+06	4.39E+04	0.00E+00	7.76E+03	-4.85E+03	0.00E+00	0.00E+00	0.00E+00
6.00	1.047	2.38E+02	4.14E+02	1.99E+04	4.18E+05	1.68E+06	4.45E+04	0.00E+00	8.03E+03	-5.07E+03	0.00E+00	0.00E+00	0.00E+00
5.50	1.142	2.44E+02	4.27E+02	1.91E+04	4.23E+05	1.69E+06	4.53E+04	0.00E+00	8.26E+03	-5.31E+03	0.00E+00	0.00E+00	0.00E+00
5.00	1.257	2.49E+02	4.42E+02	1.80E+04	4.26E+05	1.69E+06	4.64E+04	0.00E+00	8.33E+03	-5.52E+03	0.00E+00	0.00E+00	0.00E+00
4.50	1.396	2.51E+02	4.54E+02	1.68E+04	4.23E+05	1.65E+06	4.82E+04	0.00E+00	8.02E+03	-5.58E+03	0.00E+00	0.00E+00	0.00E+00
4.00	1.571	2.47E+02	4.54E+02	1.54E+04	4.10E+05	1.56E+06	5.08E+04	0.00E+00	7.07E+03	-5.23E+03	0.00E+00	0.00E+00	0.00E+00
3.50	1.795	2.37E+02	4.27E+02	1.40E+04	3.82E+05	1.43E+06	5.42E+04	0.00E+00	5.36E+03	-4.19E+03	0.00E+00	0.00E+00	0.00E+00
3.00	2.094	2.22E+02	3.66E+02	1.27E+04	3.42E+05	1.27E+06	5.79E+04	0.00E+00	3.04E+03	-2.43E+03	0.00E+00	0.00E+00	0.00E+00
2.79	2.248	2.12E+02	3.31E+02	1.23E+04	3.27E+05	1.20E+06	5.88E+04	0.00E+00	2.03E+03	-1.60E+03	0.00E+00	0.00E+00	0.00E+00
2.50	2.513	1.83E+02	2.81E+02	1.18E+04	3.09E+05	1.12E+06	5.67E+04	0.00E+00	6.87E+02	-4.61E+02	0.00E+00	0.00E+00	0.00E+00
2.16	2.902	1.34E+02	2.21E+02	1.17E+04	2.97E+05	1.05E+06	4.84E+04	0.00E+00	-5.82E+02	6.24E+02	0.00E+00	0.00E+00	0.00E+00
2.00	3.142	1.13E+02	1.80E+02	1.18E+04	2.95E+05	1.04E+06	4.47E+04	0.00E+00	-1.08E+03	1.02E+03	0.00E+00	0.00E+00	0.00E+00

DAMPING-VARIATION WITH WAVE PERIOD/FREQUENCY

PERIOD (SECS)	FREQ (RAD/S)	C 11	C 22	C 33	C 44	C 55	C 66	C 13	C 15	C 24	C 26	C 35	C 46
6.50	0.967	1.40E+01	1.82E+01	9.49E+03	1.48E+04	1.10E+05	3.55E+01	0.00E+00	1.25E+03	-5.23E+02	0.00E+00	0.00E+00	0.00E+00
6.00	1.047	2.11E+01	2.84E+01	1.04E+04	2.22E+04	1.59E+05	7.33E+01	0.00E+00	1.84E+03	-8.02E+02	0.00E+00	0.00E+00	0.00E+00
5.50	1.142	3.28E+01	4.65E+01	1.15E+04	3.48E+04	2.36E+05	1.66E+02	0.00E+00	2.80E+03	-1.28E+03	0.00E+00	0.00E+00	0.00E+00
5.00	1.257	5.20E+01	7.94E+01	1.26E+04	5.59E+04	3.54E+05	4.18E+02	0.00E+00	4.32E+03	-2.12E+03	0.00E+00	0.00E+00	0.00E+00
4.50	1.396	8.24E+01	1.38E+02	1.37E+04	8.95E+04	5.19E+05	1.15E+03	0.00E+00	6.57E+03	-3.55E+03	0.00E+00	0.00E+00	0.00E+00
4.00	1.571	1.26E+02	2.36E+02	1.47E+04	1.37E+05	7.18E+05	3.35E+03	0.00E+00	9.54E+03	-5.73E+03	0.00E+00	0.00E+00	0.00E+00
3.50	1.795	1.84E+02	3.81E+02	1.51E+04	1.88E+05	9.09E+05	9.58E+03	0.00E+00	1.28E+04	-8.53E+03	0.00E+00	0.00E+00	0.00E+00
3.00	2.094	2.72E+02	5.62E+02	1.47E+04	2.19E+05	1.03E+06	2.58E+04	0.00E+00	1.55E+04	-1.12E+04	0.00E+00	0.00E+00	0.00E+00
2.79	2.248	3.26E+02	6.34E+02	1.41E+04	2.21E+05	1.05E+06	3.85E+04	0.00E+00	1.62E+04	-1.18E+04	0.00E+00	0.00E+00	0.00E+00
2.50	2.513	4.24E+02	7.29E+02	1.28E+04	2.08E+05	1.02E+06	6.74E+04	0.00E+00	1.64E+04	-1.22E+04	0.00E+00	0.00E+00	0.00E+00
2.16	2.902	5.08E+02	8.66E+02	1.04E+04	1.76E+05	8.64E+05	9.94E+04	0.00E+00	1.57E+04	-1.15E+04	0.00E+00	0.00E+00	0.00E+00
2.00	3.142	5.30E+02	9.29E+02	8.89E+03	1.54E+05	7.36E+05	1.25E+05	0.00E+00	1.46E+04	-1.07E+04	0.00E+00	0.00E+00	0.00E+00

****HYDRODYNAMIC PARAMETERS FOR STRUCTURE 1****

TOTAL FORCES-VARIATION WITH WAVE PERIOD/FREQUENCY

PERIOD	FREQ	DIRECTION	X		Y		Z		RX		RY		RZ	
(SECS)	(RAD/S)	(DEGREES)	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE
6.50	0.967	0.00	1.93E+03	-90.63	1.07E-04	3.32	3.87E+04	-12.98	8.39E-02	179.45	1.93E+05	-90.63	9.54E-04	-78.22
6.00	1.047		2.09E+03	-91.15	2.45E-04	-5.69	3.58E+04	-16.47	3.62E-02	2.08	2.06E+05	-91.13	1.25E-03	-120.04
5.50	1.142		2.26E+03	-92.18	9.50E-05	-15.43	3.24E+04	-21.44	1.02E-02	-7.04	2.19E+05	-92.13	8.05E-04	75.65
5.00	1.257		2.41E+03	-94.30	1.70E-04	171.92	2.86E+04	-28.56	2.76E-02	176.75	2.30E+05	-94.17	8.89E-04	-136.35
4.50	1.396		2.49E+03	-98.79	1.53E-04	176.07	2.43E+04	-38.82	1.34E-02	-0.85	2.34E+05	-98.33	2.46E-04	-95.28
4.00	1.571		2.42E+03	-108.45	7.76E-05	169.38	1.93E+04	-54.24	3.54E-03	0.49	2.28E+05	-106.68	2.26E-03	88.89
3.50	1.795		2.13E+03	-130.48	6.11E-05	-178.21	1.35E+04	-80.10	1.28E-02	3.70	2.06E+05	-122.74	4.30E-04	-67.89
3.00	2.094		1.96E+03	177.77	8.71E-05	-151.19	8.34E+03	-135.16	1.34E-02	-9.58	1.65E+05	-153.03	1.18E-03	72.04
2.79	2.248		2.19E+03	149.25	3.41E-05	-116.57	7.55E+03	-171.66	2.29E-03	28.61	1.41E+05	-173.00	7.47E-04	85.31
2.50	2.513		2.67E+03	108.61	9.16E-05	177.61	8.02E+03	132.47	1.83E-02	-0.19	1.02E+05	140.84	9.36E-04	94.78
2.16	2.902		2.68E+03	44.10	7.51E-05	-23.96	7.09E+03	63.09	3.38E-03	7.25	9.03E+04	54.44	5.50E-04	75.43
2.00	3.142		2.57E+03	-7.72	1.53E-05	0.00	5.96E+03	7.40	2.22E-03	-164.05	8.47E+04	8.65	1.54E-03	67.78
6.50	0.967	30.00	1.69E+03	-90.62	1.10E+03	-89.94	3.91E+04	-12.98	3.53E+04	90.06	1.68E+05	-90.62	2.71E+03	0.01
6.00	1.047		1.84E+03	-91.12	1.21E+03	-90.01	3.63E+04	-16.47	3.81E+04	89.99	1.80E+05	-91.12	3.46E+03	0.01
5.50	1.142		2.01E+03	-92.12	1.34E+03	-90.19	3.31E+04	-21.43	4.11E+04	89.80	1.91E+05	-92.12	4.56E+03	0.01
5.00	1.257		2.17E+03	-94.14	1.48E+03	-90.68	2.95E+04	-28.52	4.38E+04	89.30	2.01E+05	-94.14	6.24E+03	-0.01
4.50	1.396		2.31E+03	-98.27	1.62E+03	-91.89	2.56E+04	-38.67	4.52E+04	88.03	2.06E+05	-98.26	8.81E+03	-0.14
4.00	1.571		2.37E+03	-106.55	1.69E+03	-94.74	2.12E+04	-53.48	4.32E+04	84.89	2.02E+05	-106.52	1.27E+04	-0.76
3.50	1.795		2.30E+03	-122.75	1.58E+03	-100.87	1.62E+04	-76.15	3.45E+04	77.27	1.87E+05	-122.40	1.81E+04	-3.22
3.00	2.094		2.05E+03	-154.86	1.05E+03	-114.83	1.09E+04	-115.71	1.62E+04	52.80	1.60E+05	-151.91	2.51E+04	-10.19
2.79	2.248		1.92E+03	-176.49	6.36E+02	-130.59	8.90E+03	-140.71	8.06E+03	11.71	1.46E+05	-169.99	2.80E+04	-14.28
2.50	2.513		1.82E+03	140.53	3.95E+02	108.94	6.45E+03	168.21	1.11E+04	-96.21	1.21E+05	156.12	2.92E+04	-20.23
2.16	2.902		1.82E+03	75.77	1.16E+03	60.47	5.62E+03	82.99	1.73E+04	-166.18	7.08E+04	98.07	1.60E+04	-40.65
2.00	3.142		1.72E+03	39.82	1.02E+03	44.38	5.23E+03	43.14	1.74E+04	150.65	4.60E+04	39.75	7.84E+03	-106.86
6.50	0.967	60.00	1.01E+03	-90.60	1.93E+03	-89.94	4.00E+04	-12.98	6.27E+04	90.06	9.77E+04	-90.62	2.69E+03	0.01
6.00	1.047		1.11E+03	-91.08	2.14E+03	-90.01	3.74E+04	-16.46	6.84E+04	89.99	1.05E+05	-91.11	3.42E+03	0.01
5.50	1.142		1.22E+03	-92.01	2.40E+03	-90.21	3.44E+04	-21.42	7.47E+04	89.79	1.12E+05	-92.09	4.50E+03	0.01
5.00	1.257		1.36E+03	-93.85	2.69E+03	-90.73	3.13E+04	-28.46	8.13E+04	89.27	1.18E+05	-94.08	6.10E+03	-0.01
4.50	1.396		1.51E+03	-97.39	3.00E+03	-92.05	2.81E+04	-38.40	8.71E+04	87.94	1.23E+05	-98.12	8.50E+03	-0.16
4.00	1.571		1.69E+03	-103.73	3.27E+03	-95.27	2.49E+04	-52.32	8.96E+04	84.69	1.22E+05	-106.22	1.19E+04	-0.89
3.50	1.795		1.90E+03	-113.47	3.40E+03	-102.55	2.16E+04	-71.27	8.53E+04	77.21	1.17E+05	-121.82	1.59E+04	-4.32
3.00	2.094		2.07E+03	-125.47	3.26E+03	-117.44	1.77E+04	-97.88	7.01E+04	60.72	1.07E+05	-151.03	1.89E+04	-19.01
2.79	2.248		2.01E+03	-131.09	3.07E+03	-126.94	1.57E+04	-112.28	5.99E+04	48.80	1.03E+05	-168.59	2.01E+04	-32.95
2.50	2.513		1.61E+03	-143.47	2.58E+03	-144.51	1.22E+04	-137.72	4.24E+04	21.10	9.78E+04	159.89	2.46E+04	-59.61
2.16	2.902		8.62E+02	-170.69	1.33E+03	-165.22	6.61E+03	-176.54	2.41E+04	-37.71	8.33E+04	112.02	2.80E+04	-86.51
2.00	3.142		4.50E+02	-173.17	4.58E+02	-163.39	3.32E+03	156.59	1.69E+04	-80.28	6.82E+04	81.94	2.24E+04	-103.95

**** HYDRODYNAMIC PARAMETERS FOR STRUCTURE 1 ****

TOTAL FORCES-VARIATION WITH WAVE PERIOD/FREQUENCY

PERIOD (SECS)	FREQ (RAD/S)	DIRECTION (DEGREES)	X AMP	X PHASE	Y AMP	Y PHASE	Z AMP	Z PHASE	RX AMP	RX PHASE	RY AMP	RY PHASE	RZ AMP	RZ PHASE
6.50	0.967	90.00	1.60E-04	-85.09	2.25E+03	-89.95	4.04E+04	-12.98	7.34E+04	90.05	6.52E-02	-165.31	2.34E-03	-2.04
6.00	1.047		1.88E-04	-105.15	2.50E+03	-90.02	3.79E+04	-16.46	8.03E+04	89.98	4.38E-02	-17.29	1.42E-03	121.57
5.50	1.142		1.96E-04	-82.84	2.81E+03	-90.22	3.51E+04	-21.41	8.83E+04	89.78	7.21E-02	-16.78	7.23E-04	30.04
5.00	1.257		2.28E-04	-113.34	3.17E+03	-90.76	3.22E+04	-28.44	9.71E+04	89.25	3.02E-02	-143.81	5.61E-04	-92.60
4.50	1.396		3.34E-04	-111.05	3.57E+03	-92.13	2.93E+04	-38.29	1.06E+05	87.90	2.61E-02	-116.60	1.45E-03	-5.29
4.00	1.571		2.86E-04	-104.45	3.96E+03	-95.56	2.67E+04	-51.87	1.12E+05	84.60	9.49E-02	-166.62	1.75E-03	4.98
3.50	1.795		3.18E-04	-110.72	4.26E+03	-103.56	2.42E+04	-69.70	1.15E+05	77.13	4.27E-02	-20.26	3.46E-03	45.17
3.00	2.094		4.34E-04	-109.54	4.43E+03	-120.53	2.11E+04	-94.02	1.10E+05	62.05	3.25E-02	-29.18	2.06E-03	39.38
2.79	2.248		4.05E-04	-120.21	4.45E+03	-131.65	1.92E+04	-107.97	1.06E+05	52.46	1.59E-02	-139.95	3.79E-03	-75.68
2.50	2.513		4.43E-04	-116.70	4.37E+03	-155.25	1.61E+04	-136.61	9.42E+04	32.95	3.27E-02	146.25	4.32E-03	-97.30
2.16	2.902		1.63E-04	147.86	4.49E+03	160.73	1.35E+04	173.69	7.29E+04	-3.79	2.09E-02	86.99	1.13E-02	-143.37
2.00	3.142		3.03E-04	102.72	4.64E+03	132.90	1.25E+04	142.09	5.97E+04	-32.89	2.31E-02	68.56	1.68E-02	-162.33

**** HYDRODYNAMIC PARAMETERS FOR STRUCTURE 1 ****

R.A.O.S-VARIATION WITH WAVE PERIOD/FREQUENCY

PERIOD (SECS)	FREQ (RAD/S)	DIRECTION (DEGREES)	X AMP	X PHASE	Y AMP	Y PHASE	Z AMP	Z PHASE	RX AMP	RX PHASE	RY AMP	RY PHASE	RZ AMP	RZ PHASE
6.50	0.967	0.00	0.9922	90.06	0.0000	-175.73	0.9385	-0.12	0.0000	179.35	1.7634	-90.01	0.0000	101.77
6.00	1.047		0.9393	90.11	0.0000	154.98	0.9204	-0.19	0.0000	2.53	1.9906	-90.03	0.0000	59.95
5.50	1.142		0.8826	90.17	0.0000	100.65	0.8931	-0.29	0.0000	-1.04	2.2811	-90.07	0.0000	-104.37
5.00	1.257		0.8165	90.30	0.0000	-25.22	0.8497	-0.49	0.0000	174.55	2.6556	-90.15	0.0000	43.62
4.50	1.396		0.7286	90.57	0.0000	11.56	0.7779	-1.01	0.0000	4.14	3.1332	-90.29	0.0000	84.63
4.00	1.571		0.5973	91.29	0.0000	22.67	0.6572	-2.83	0.0000	8.98	3.7121	-90.41	0.0000	-91.33
3.50	1.795		0.3898	94.56	0.0000	53.73	0.4701	-9.84	0.0000	17.60	4.3110	-89.28	0.0000	111.55
3.00	2.094		0.0798	123.16	0.0000	77.32	0.2702	-39.02	0.0000	24.40	4.1417	-84.33	0.0000	-109.24
2.79	2.248		0.0690	-115.97	0.0000	101.87	0.2248	-62.42	0.0000	42.56	3.3708	-84.01	0.0000	-96.46
2.50	2.513		0.1488	-106.61	0.0000	-174.28	0.1925	-97.92	0.0000	106.77	1.9016	-102.45	0.0000	-88.00
2.16	2.902		0.1340	-159.38	0.0000	-171.06	0.1132	-145.66	0.0000	146.49	1.0871	-162.01	0.0000	-108.18
2.00	3.142		0.1235	154.52	0.0000	103.65	0.0739	167.16	0.0000	-9.24	0.7574	163.22	0.0000	-116.43
6.50	0.967	30.00	0.8710	90.06	0.5007	90.00	0.9490	-0.12	0.8739	90.00	1.5328	-90.01	0.3088	-180.00
6.00	1.047		0.8280	90.10	0.4757	90.01	0.9341	-0.18	0.9831	89.99	1.7321	-90.03	0.3355	-180.00
5.50	1.142		0.7831	90.17	0.4499	90.01	0.9117	-0.28	1.1198	89.97	1.9883	-90.07	0.3711	179.99
5.00	1.257		0.7325	90.29	0.4209	90.01	0.8763	-0.46	1.2895	89.89	2.3211	-90.15	0.4183	179.95
4.50	1.396		0.6669	90.53	0.3839	90.00	0.8181	-0.86	1.4898	89.71	2.7519	-90.31	0.4770	179.77
4.00	1.571		0.5700	91.13	0.3296	89.96	0.7199	-2.06	1.6886	89.27	3.2915	-90.47	0.5399	179.02
3.50	1.795		0.4155	93.68	0.2448	89.90	0.5621	-5.89	1.7743	88.30	3.9121	-89.49	0.5864	176.22
3.00	2.094		0.1642	105.65	0.1179	86.97	0.3525	-19.57	1.3496	82.38	4.0680	-84.10	0.5927	168.53
2.79	2.248		0.0511	131.29	0.0653	76.97	0.2649	-31.48	0.9332	62.72	3.5779	-81.60	0.5742	163.94
2.50	2.513		0.0786	-107.99	0.0161	76.87	0.1550	-62.19	1.1615	14.86	2.3135	-86.12	0.4798	156.99
2.16	2.902		0.0988	-129.84	0.0357	-143.76	0.0898	-125.76	0.8956	-15.91	0.8412	-117.68	0.2001	135.74
2.00	3.142		0.0768	-156.20	0.0297	-151.78	0.0648	-157.10	0.6152	-46.60	0.4205	-166.43	0.0842	68.92
6.50	0.967	60.00	0.5164	90.06	0.8835	90.00	0.9701	-0.13	1.5555	90.00	0.8913	-90.01	0.3063	-180.00
6.00	1.047		0.4948	90.10	0.8442	90.01	0.9615	-0.18	1.7647	89.99	1.0094	-90.03	0.3319	-180.00
5.50	1.142		0.4739	90.16	0.8054	90.01	0.9490	-0.27	2.0365	89.96	1.1624	-90.07	0.3657	179.99
5.00	1.257		0.4523	90.26	0.7647	90.01	0.9295	-0.40	2.3967	89.89	1.3640	-90.16	0.4092	179.95
4.50	1.396		0.4268	90.45	0.7158	90.01	0.8981	-0.59	2.8782	89.71	1.6312	-90.34	0.4605	179.75
4.00	1.571		0.3907	90.87	0.6469	90.05	0.8448	-0.90	3.5215	89.34	1.9821	-90.59	0.5068	178.89
3.50	1.795		0.3320	92.54	0.5412	90.71	0.7496	-1.00	4.4181	89.07	2.4373	-89.95	0.5146	175.12
3.00	2.094		0.2198	97.94	0.3645	97.17	0.5727	-1.74	5.7889	93.21	2.7840	-84.76	0.4465	159.71
2.79	2.248		0.1524	99.66	0.2396	108.02	0.4676	-3.04	6.3533	102.75	2.6379	-81.32	0.4117	145.27
2.50	2.513		0.0638	94.37	0.0149	47.92	0.2929	-8.12	4.4114	129.12	1.9774	-81.87	0.4043	117.60
2.16	2.902		0.0109	78.56	0.0344	-11.85	0.1057	-25.29	1.2335	113.63	1.0358	-100.56	0.3496	89.88
2.00	3.142		0.0093	98.51	0.0053	27.60	0.0411	-43.66	0.5696	83.69	0.6221	-119.40	0.2404	71.84

**** HYDRODYNAMIC PARAMETERS FOR STRUCTURE 1 ****

R.A.O.S-VARIATION WITH WAVE PERIOD/FREQUENCY

PERIOD	FREQ	DIRECTION	X		Y		Z		RX		RY		RZ	
(SECS)	(RAD/S)	(DEGREES)	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE
6.50	0.967	90.00	0.0000	76.97	1.0295	90.00	0.9806	-0.13	1.8205	90.00	0.0000	-160.99	0.0000	177.96
6.00	1.047		0.0000	101.78	0.9864	90.01	0.9752	-0.18	2.0737	89.99	0.0000	-11.70	0.0000	-58.43
5.50	1.142		0.0000	137.75	0.9450	90.01	0.9675	-0.26	2.4083	89.96	0.0000	-11.61	0.0000	-149.97
5.00	1.257		0.0000	69.31	0.9032	90.01	0.9559	-0.37	2.8636	89.89	0.0000	-118.82	0.0000	87.37
4.50	1.396		0.0000	80.59	0.8550	90.02	0.9379	-0.48	3.5008	89.72	0.0000	-79.64	0.0000	174.63
4.00	1.571		0.0000	72.31	0.7889	90.09	0.9067	-0.46	4.4285	89.37	0.0000	-147.01	0.0000	-175.24
3.50	1.795		0.0000	-107.94	0.6874	91.10	0.8422	0.56	5.9517	89.35	0.0000	18.57	0.0000	-135.39
3.00	2.094		0.0000	-27.08	0.4981	101.08	0.6823	2.12	9.0994	95.55	0.0000	45.81	0.0000	-141.90
2.79	2.248		0.0000	63.76	0.3292	120.22	0.5710	1.26	11.1030	107.85	0.0000	-22.06	0.0000	102.55
2.50	2.513		0.0000	105.64	0.1302	-80.78	0.3870	-7.00	9.4094	142.77	0.0000	-98.35	0.0000	79.92
2.16	2.902		0.0000	103.99	0.2388	-51.76	0.2150	-35.05	3.3947	144.48	0.0000	-134.76	0.0000	33.02
2.00	3.142		0.0000	-112.84	0.2184	-68.24	0.1549	-58.15	1.9302	123.54	0.0000	-139.47	0.0000	13.45

* * * * H Y D R O D Y N A M I C   P A R A M E T E R S   F O R   S T R U C T U R E   1 * * * *

VEL R.A.O.S-VARIATION WITH WAVE PERIOD/FREQUENCY

PERIOD	FREQ	DIRECTION	X		Y		Z		RX		RY		RZ	
(SECS)	(RAD/S)	(DEGREES)	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE
6.50	0.967	0.00	0.9591	0.06	0.0000	94.27	0.9072	-90.12	0.0000	89.35	1.7046	179.99	0.0000	11.77
6.00	1.047		0.9836	0.11	0.0000	64.98	0.9638	-90.19	0.0000	-87.47	2.0845	179.97	0.0000	-30.05
5.50	1.142		1.0083	0.17	0.0000	10.65	1.0203	-90.29	0.0000	-91.04	2.6059	179.93	0.0000	165.63
5.00	1.257		1.0260	0.30	0.0000	-115.22	1.0677	-90.49	0.0000	84.55	3.3371	179.85	0.0000	-46.38
4.50	1.396		1.0173	0.57	0.0000	-78.44	1.0861	-91.01	0.0000	-85.86	4.3748	179.71	0.0000	-5.37
4.00	1.571		0.9382	1.29	0.0000	-67.33	1.0323	-92.83	0.0000	-81.02	5.8310	179.59	0.0000	178.67
3.50	1.795		0.6998	4.56	0.0000	-36.27	0.8440	-99.84	0.0000	-72.40	7.7391	-179.28	0.0000	21.55
3.00	2.094		0.1672	33.16	0.0000	-12.68	0.5658	-129.02	0.0000	-65.60	8.6743	-174.33	0.0000	160.76
2.79	2.248		0.1552	154.03	0.0000	11.87	0.5053	-152.42	0.0000	-47.44	7.5776	-174.01	0.0000	173.54
2.50	2.513		0.3739	163.39	0.0000	95.72	0.4839	172.08	0.0000	16.77	4.7792	167.55	0.0000	-178.00
2.16	2.902		0.3890	110.62	0.0000	98.94	0.3286	124.34	0.0000	56.49	3.1551	107.99	0.0000	161.82
2.00	3.142		0.3881	64.52	0.0000	13.65	0.2320	77.16	0.0000	-99.24	2.3795	73.22	0.0000	153.57
6.50	0.967	30.00	0.8419	0.06	0.4840	0.00	0.9174	-90.12	0.8447	0.00	1.4816	179.99	0.2985	90.00
6.00	1.047		0.8670	0.10	0.4982	0.01	0.9782	-90.18	1.0295	-0.01	1.8139	179.97	0.3513	90.00
5.50	1.142		0.8946	0.17	0.5139	0.01	1.0416	-90.28	1.2792	-0.03	2.2714	179.93	0.4240	89.99
5.00	1.257		0.9205	0.29	0.5289	0.01	1.1012	-90.46	1.6205	-0.11	2.9168	179.85	0.5256	89.95
4.50	1.396		0.9312	0.53	0.5360	0.00	1.1422	-90.86	2.0801	-0.29	3.8424	179.69	0.6661	89.77
4.00	1.571		0.8954	1.13	0.5177	-0.04	1.1307	-92.06	2.6525	-0.73	5.1702	179.53	0.8480	89.02
3.50	1.795		0.7459	3.68	0.4394	-0.10	1.0091	-95.89	3.1852	-1.70	7.0229	-179.49	1.0527	86.22
3.00	2.094		0.3439	15.65	0.2469	-3.03	0.7383	-109.57	2.8265	-7.62	8.5200	-174.10	1.2414	78.53
2.79	2.248		0.1148	41.29	0.1469	-13.03	0.5956	-121.48	2.0978	-27.28	8.0431	-171.60	1.2909	73.94
2.50	2.513		0.1976	162.01	0.0405	-13.13	0.3895	-152.19	2.9191	-75.14	5.8145	-176.12	1.2058	66.99
2.16	2.902		0.2869	140.16	0.1035	126.24	0.2606	144.24	2.5992	-105.91	2.4413	152.32	0.5806	45.74
2.00	3.142		0.2412	113.80	0.0932	118.22	0.2034	112.90	1.9328	-136.60	1.3212	103.57	0.2645	-21.08
6.50	0.967	60.00	0.4991	0.06	0.8540	0.00	0.9377	-90.13	1.5036	0.00	0.8616	179.99	0.2961	90.00
6.00	1.047		0.5182	0.10	0.8840	0.01	1.0069	-90.18	1.8479	-0.01	1.0570	179.97	0.3476	90.00
5.50	1.142		0.5414	0.16	0.9201	0.01	1.0841	-90.27	2.3265	-0.04	1.3279	179.93	0.4178	89.99
5.00	1.257		0.5684	0.26	0.9609	0.01	1.1680	-90.40	3.0118	-0.11	1.7140	179.84	0.5142	89.95
4.50	1.396		0.5960	0.45	0.9994	0.01	1.2540	-90.59	4.0188	-0.29	2.2776	179.66	0.6430	89.75
4.00	1.571		0.6137	0.87	1.0162	0.05	1.3270	-90.90	5.5316	-0.66	3.1134	179.41	0.7961	88.89
3.50	1.795		0.5960	2.54	0.9716	0.71	1.3457	-91.00	7.9313	-0.93	4.3755	-179.95	0.9238	85.12
3.00	2.094		0.4604	7.94	0.7633	7.17	1.1995	-91.74	12.1243	3.21	5.8308	-174.76	0.9351	69.71
2.79	2.248		0.3426	9.66	0.5386	18.02	1.0511	-93.04	14.2824	12.75	5.9299	-171.32	0.9254	55.27
2.50	2.513		0.1603	4.37	0.0374	-42.08	0.7361	-98.12	11.0870	39.12	4.9697	-171.87	1.0160	27.60
2.16	2.902		0.0317	-11.44	0.0998	-101.85	0.3066	-115.29	3.5799	23.63	3.0059	169.44	1.0147	-0.12
2.00	3.142		0.0292	8.51	0.0166	-62.40	0.1293	-133.66	1.7896	-6.31	1.9544	150.60	0.7553	-18.16

**** HYDRODYNAMIC PARAMETERS FOR STRUCTURE 1 ****

VEL R.A.O.S-VARIATION WITH WAVE PERIOD/FREQUENCY

PERIOD	FREQ	DIRECTION	X		Y		Z		RX		RY		RZ	
(SECS)	(RAD/S)	(DEGREES)	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE
6.50	0.967	90.00	0.0000	-13.03	0.9952	0.00	0.9479	-90.13	1.7598	0.00	0.0000	109.01	0.0000	87.96
6.00	1.047		0.0000	11.78	1.0329	0.01	1.0212	-90.18	2.1716	-0.01	0.0000	-101.70	0.0000	-148.43
5.50	1.142		0.0000	47.75	1.0795	0.01	1.1053	-90.26	2.7512	-0.04	0.0000	-101.61	0.0000	120.03
5.00	1.257		0.0000	-20.69	1.1350	0.01	1.2013	-90.37	3.5985	-0.11	0.0000	151.18	0.0000	-2.63
4.50	1.396		0.0000	-9.41	1.1938	0.02	1.3095	-90.48	4.8880	-0.28	0.0000	-169.64	0.0000	84.63
4.00	1.571		0.0000	-17.69	1.2392	0.09	1.4242	-90.46	6.9562	-0.63	0.0000	122.99	0.0000	94.76
3.50	1.795		0.0000	162.06	1.2341	1.10	1.5118	-89.44	10.6844	-0.65	0.0000	-71.43	0.0000	134.61
3.00	2.094		0.0000	-117.08	1.0432	11.08	1.4290	-87.88	19.0576	5.55	0.0000	-44.19	0.0000	128.10
2.79	2.248		0.0000	-26.24	0.7400	30.22	1.2837	-88.74	24.9596	17.85	0.0000	-112.06	0.0000	12.55
2.50	2.513		0.0000	15.64	0.3273	-170.78	0.9727	-97.00	23.6485	52.77	0.0000	171.65	0.0000	-10.08
2.16	2.902		0.0000	13.99	0.6930	-141.76	0.6239	-125.05	9.8519	54.48	0.0000	135.24	0.0000	-56.98
2.00	3.142		0.0000	157.16	0.6860	-158.24	0.4867	-148.15	6.0640	33.54	0.0000	130.53	0.0000	-76.55

* * * * HYDRODYNAMIC PARAMETERS FOR STRUCTURE 1 * * * *

ACC R.A.O.S-VARIATION WITH WAVE PERIOD/FREQUENCY

PERIOD	FREQ	DIRECTION	X		Y		Z		RX		RY		RZ	
(SECS)	(RAD/S)	(DEGREES)	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE
6.50	0.967	0.00	0.9271	-89.94	0.0000	4.27	0.8769	179.88	0.0000	-0.65	1.6477	89.99	0.0000	-78.23
6.00	1.047		1.0300	-89.89	0.0000	-25.02	1.0093	179.81	0.0000	-177.47	2.1829	89.97	0.0000	-120.05
5.50	1.142		1.1519	-89.83	0.0000	-79.35	1.1655	179.71	0.0000	178.96	2.9770	89.93	0.0000	75.63
5.00	1.257		1.2893	-89.70	0.0000	154.78	1.3417	179.51	0.0000	-5.45	4.1936	89.85	0.0000	-136.38
4.50	1.396		1.4204	-89.43	0.0000	-168.44	1.5165	178.99	0.0000	-175.86	6.1084	89.71	0.0000	-95.37
4.00	1.571		1.4737	-88.71	0.0000	-157.33	1.6215	177.17	0.0000	-171.02	9.1593	89.59	0.0000	88.67
3.50	1.795		1.2563	-85.44	0.0000	-126.27	1.5151	170.16	0.0000	-162.40	13.8931	90.72	0.0000	-68.45
3.00	2.094		0.3502	-56.84	0.0000	-102.68	1.1851	140.98	0.0000	-155.60	18.1675	95.67	0.0000	70.76
2.79	2.248		0.3489	64.03	0.0000	-78.13	1.1359	117.58	0.0000	-137.44	17.0344	95.99	0.0000	83.54
2.50	2.513		0.9397	73.39	0.0000	5.72	1.2162	82.08	0.0000	-73.23	12.0114	77.55	0.0000	92.00
2.16	2.902		1.1290	20.62	0.0000	8.94	0.9536	34.34	0.0000	-33.51	9.1566	17.99	0.0000	71.82
2.00	3.142		1.2193	-25.48	0.0000	-76.35	0.7290	-12.84	0.0000	170.76	7.4755	-16.78	0.0000	63.57
6.50	0.967	30.00	0.8138	-89.94	0.4678	-90.00	0.8868	179.88	0.8166	-90.00	1.4322	89.99	0.2885	0.00
6.00	1.047		0.9080	-89.90	0.5217	-89.99	1.0244	179.82	1.0781	-90.01	1.8995	89.97	0.3679	0.00
5.50	1.142		1.0220	-89.83	0.5871	-89.99	1.1899	179.72	1.4614	-90.03	2.5948	89.93	0.4844	-0.01
5.00	1.257		1.1567	-89.71	0.6647	-89.99	1.3838	179.54	2.0364	-90.11	3.6654	89.85	0.6605	-0.05
4.50	1.396		1.3002	-89.47	0.7484	-90.00	1.5949	179.14	2.9044	-90.29	5.3650	89.69	0.9300	-0.23
4.00	1.571		1.4065	-88.87	0.8132	-90.04	1.7762	177.94	4.1666	-90.73	8.1214	89.53	1.3321	-0.98
3.50	1.795		1.3390	-86.32	0.7888	-90.10	1.8116	174.11	5.7181	-91.70	12.6075	90.51	1.8899	-3.78
3.00	2.094		0.7204	-74.35	0.5172	-93.03	1.5462	160.43	5.9198	-97.62	17.8442	95.90	2.6000	-11.47
2.79	2.248		0.2580	-48.71	0.3302	-103.03	1.3389	148.52	4.7159	-117.28	18.0809	98.40	2.9019	-16.06
2.50	2.513		0.4966	72.01	0.1019	-103.13	0.9788	117.81	7.3365	-165.14	14.6134	93.88	3.0305	-23.01
2.16	2.902		0.8325	50.16	0.3005	36.24	0.7564	54.24	7.5434	164.09	7.0851	62.32	1.6851	-44.26
2.00	3.142		0.7578	23.80	0.2929	28.22	0.6391	22.90	6.0722	133.40	4.1505	13.57	0.8309	-111.08
6.50	0.967	60.00	0.4825	-89.94	0.8255	-90.00	0.9065	179.87	1.4535	-90.00	0.8329	89.99	0.2862	0.00
6.00	1.047		0.5426	-89.90	0.9258	-89.99	1.0544	179.82	1.9352	-90.01	1.1069	89.97	0.3640	0.00
5.50	1.142		0.6184	-89.84	1.0511	-89.99	1.2385	179.73	2.6577	-90.04	1.5170	89.93	0.4773	-0.01
5.00	1.257		0.7143	-89.74	1.2075	-89.99	1.4678	179.60	3.7847	-90.11	2.1539	89.84	0.6462	-0.05
4.50	1.396		0.8322	-89.55	1.3954	-89.99	1.7509	179.41	5.6113	-90.29	3.1801	89.66	0.8978	-0.25
4.00	1.571		0.9640	-89.13	1.5962	-89.95	2.0845	179.10	8.6890	-90.66	4.8906	89.41	1.2505	-1.11
3.50	1.795		1.0700	-87.46	1.7443	-89.29	2.4158	179.00	14.2383	-90.93	7.8548	90.05	1.6584	-4.88
3.00	2.094		0.9642	-82.06	1.5987	-82.83	2.5123	178.26	25.3931	-86.79	12.2120	95.24	1.9585	-20.29
2.79	2.248		0.7702	-80.34	1.2109	-71.98	2.3629	176.96	32.1069	-77.25	13.3305	98.68	2.0803	-34.73
2.50	2.513		0.4028	-85.63	0.0939	-132.08	1.8501	171.88	27.8647	-50.88	12.4903	98.13	2.5536	-62.40
2.16	2.902		0.0920	-101.44	0.2897	168.15	0.8899	154.71	10.3894	-66.37	8.7238	79.44	2.9448	-90.12
2.00	3.142		0.0919	-81.49	0.0521	-152.40	0.4061	136.34	5.6221	-96.31	6.1399	60.60	2.3729	-108.16

*** * * * HYDRODYNAMIC PARAMETERS FOR STRUCTURE 1 * * * ***

ACC R.A.O.S-VARIATION WITH WAVE PERIOD/FREQUENCY

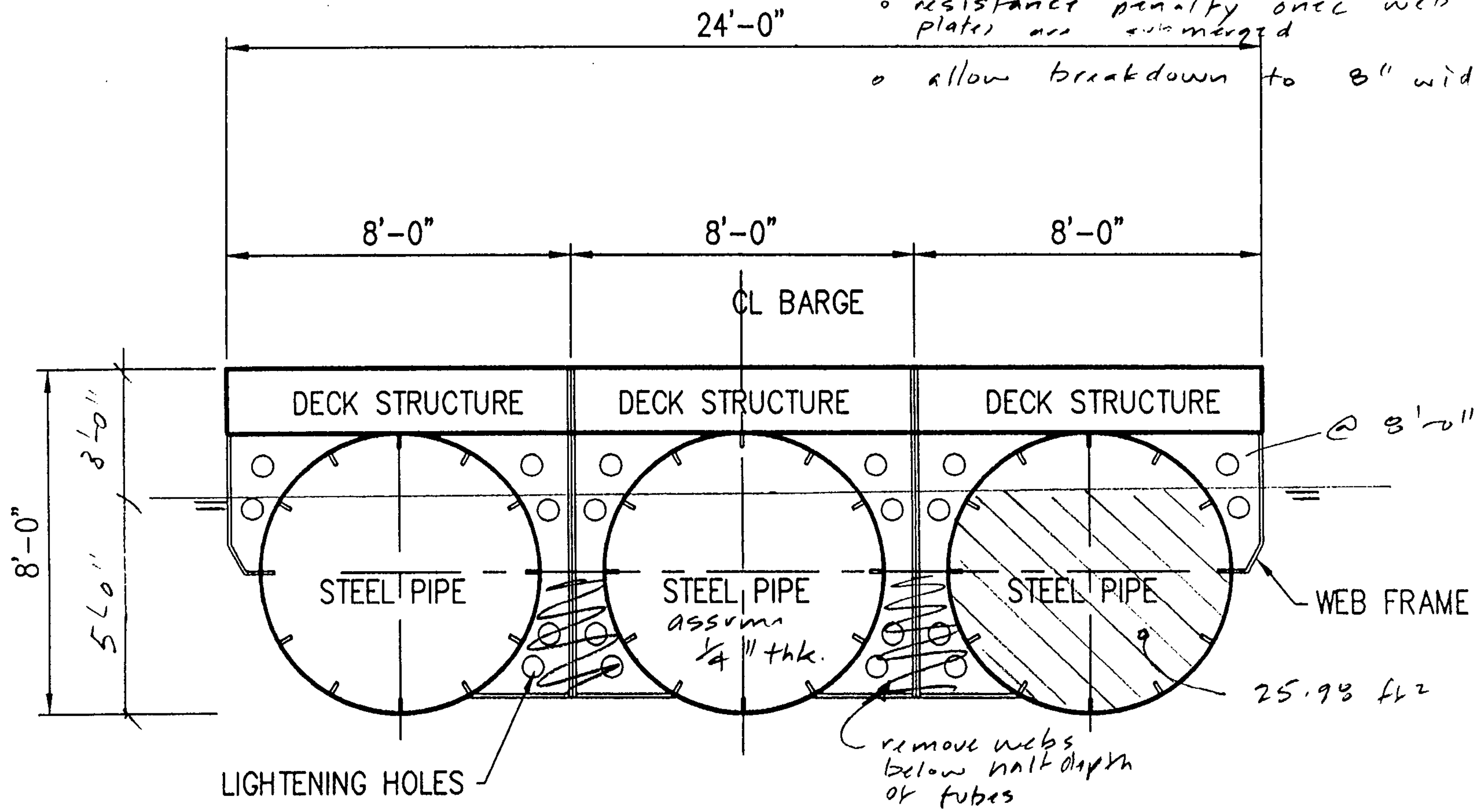
PERIOD	FREQ	DIRECTION	X		Y		Z		RX		RY		RZ	
(SECS)	(RAD/S)	(DEGREES)	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE	AMP	PHASE
6.50	0.967	90.00	0.0000	-103.03	0.9620	-90.00	0.9163	179.87	1.7011	-90.00	0.0000	19.01	0.0000	-2.04
6.00	1.047		0.0000	-78.22	1.0817	-89.99	1.0694	179.82	2.2741	-90.01	0.0000	168.30	0.0000	121.57
5.50	1.142		0.0000	-42.25	1.2332	-89.99	1.2627	179.74	3.1430	-90.04	0.0000	168.39	0.0000	30.03
5.00	1.257		0.0000	-110.69	1.4262	-89.99	1.5096	179.63	4.5220	-90.11	0.0000	61.18	0.0000	-92.63
4.50	1.396		0.0000	-99.41	1.6669	-89.98	1.8284	179.52	6.8249	-90.28	0.0000	100.36	0.0000	-5.37
4.00	1.571		0.0000	-107.69	1.9465	-89.91	2.2372	179.54	10.9268	-90.63	0.0000	32.99	0.0000	4.76
3.50	1.795		0.0000	72.06	2.2154	-88.90	2.7141	-179.44	19.1806	-90.65	0.0000	-161.43	0.0000	44.61
3.00	2.094		0.0000	152.92	2.1850	-78.92	2.9929	-177.88	39.9142	-84.45	0.0000	-134.19	0.0000	38.10
2.79	2.248		0.0000	-116.24	1.6635	-59.78	2.8857	-178.74	56.1093	-72.15	0.0000	157.94	0.0000	-77.45
2.50	2.513		0.0000	-74.36	0.8226	99.22	2.4446	173.00	59.4352	-37.23	0.0000	81.65	0.0000	-100.08
2.16	2.902		0.0000	-76.01	2.0113	128.24	1.8108	144.95	28.5918	-35.52	0.0000	45.24	0.0000	-146.98
2.00	3.142		0.0000	67.16	2.1553	111.76	1.5291	121.85	19.0506	-56.46	0.0000	40.53	0.0000	-166.55

APPENDIX C

Brainstorming Concepts

Evaluation:

- about same weight
- less than 3 ft freeboard full load
- extensive damping potential
- resistance penalty once web plates are submerged
- allow breakdown to 8' widths



Approximate weight

Deck	22600
tubes 2450 X 10.2	24990
stiffeners	8200
webs	3100
	58890 #

CONCEPT 1

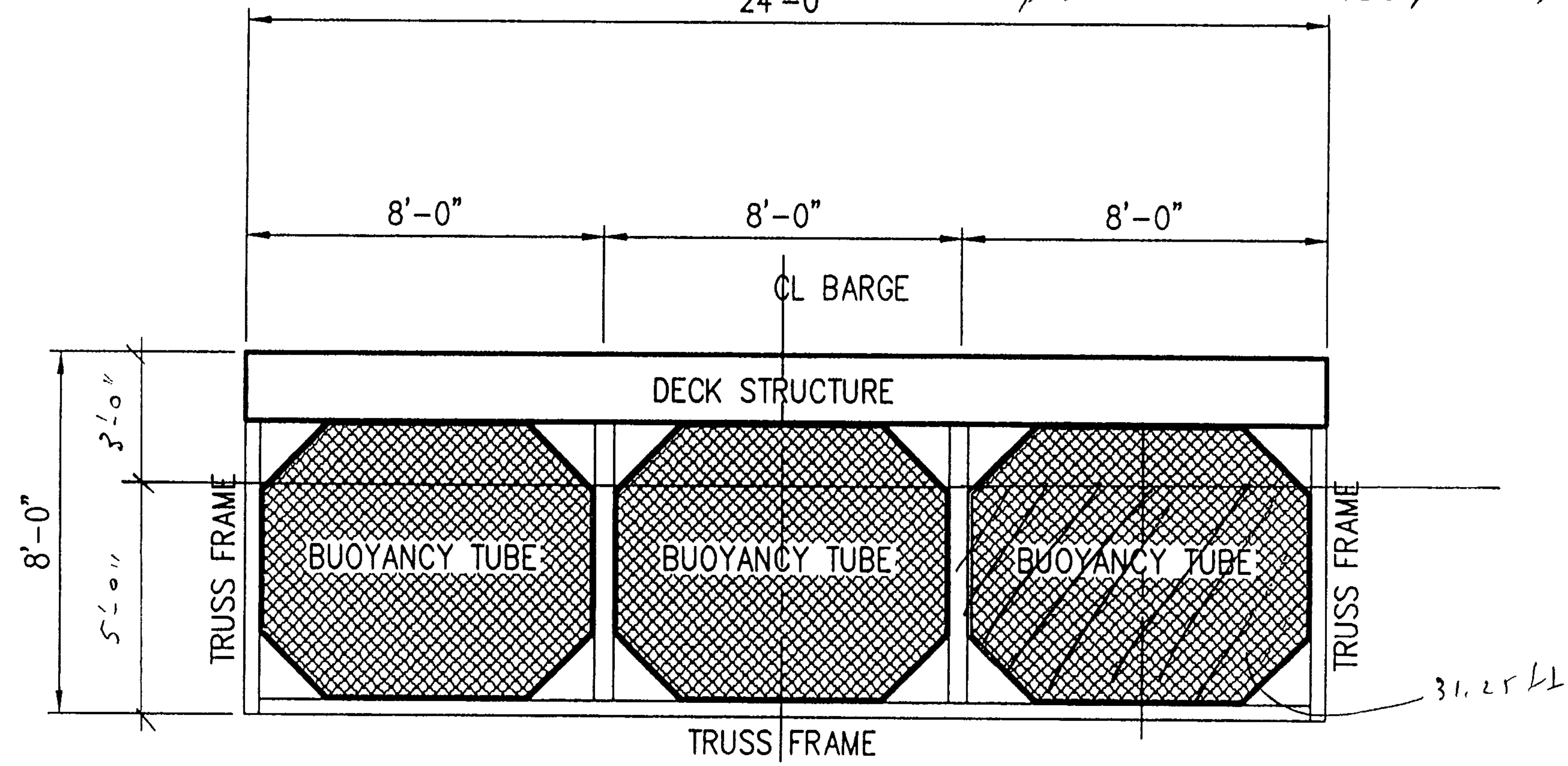
Displacement at 3' freeboard

$$\Delta = \frac{(3)(25.98)(40)}{35} = 88.97 \text{ LT}$$

$$C_B = \frac{(3)(25.98)(40)}{(24)(40)(5)} = 0.65$$

Evaluation

- about 57% wt
- greater than 4 ft at max load
- possible damping
- possible resistance penalty



Approximate wt

Deck	22600
buoyancy units	12000
trusses (4x4x.188)	4000
	38600

CONCEPT 2

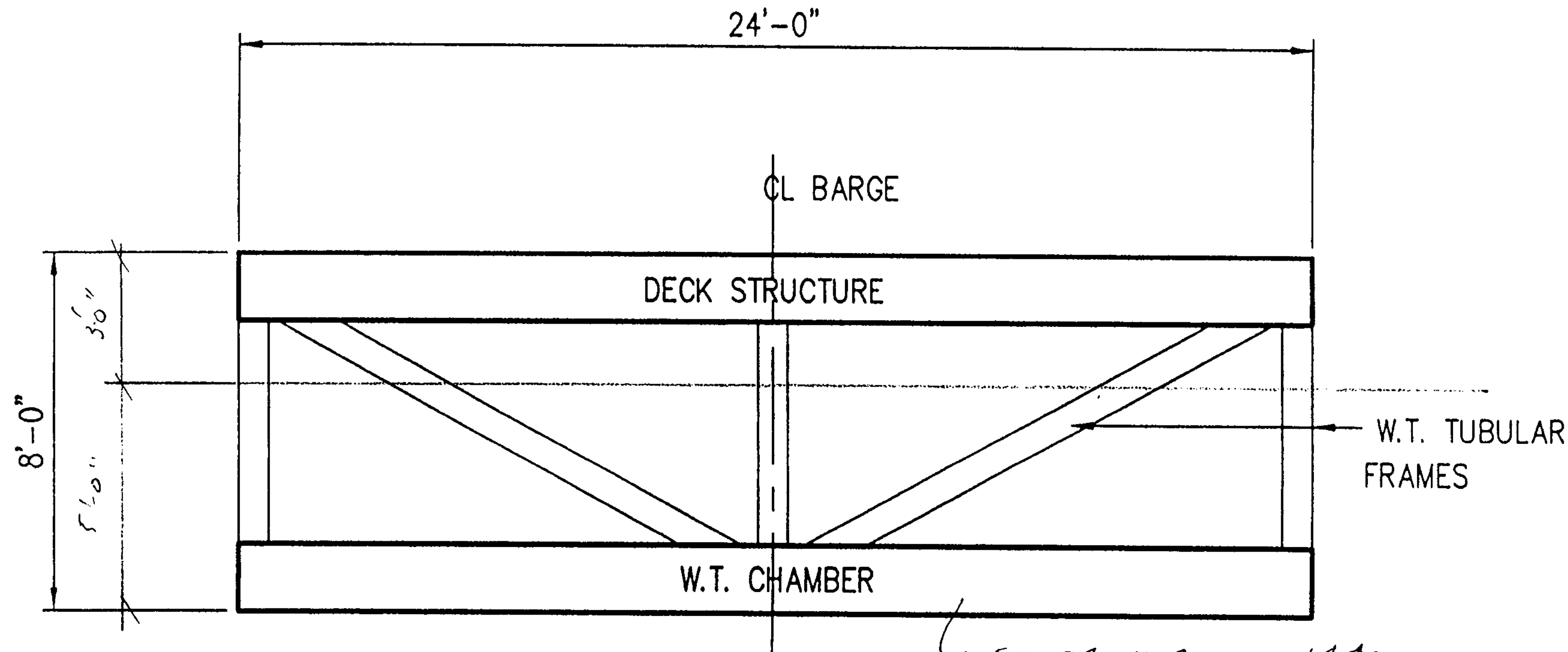
Displacement at 3' freeboard

$$\Delta = \frac{(3)(31.25)(40)}{35} = 107.14 \text{ LT}$$

$$C_B = \frac{(3)(31.25)(40)}{(24)(40)(5)} = 0.78$$

Evaluation:

- 70% wt
- insufficient displacement to support full load
- major resistance penalty
- significant motions improvement



$(1.5 \times 24 \times 40 = 1440$

Approximate wt

Deck	22600
chamber	20000
truss	3150
	45750 #

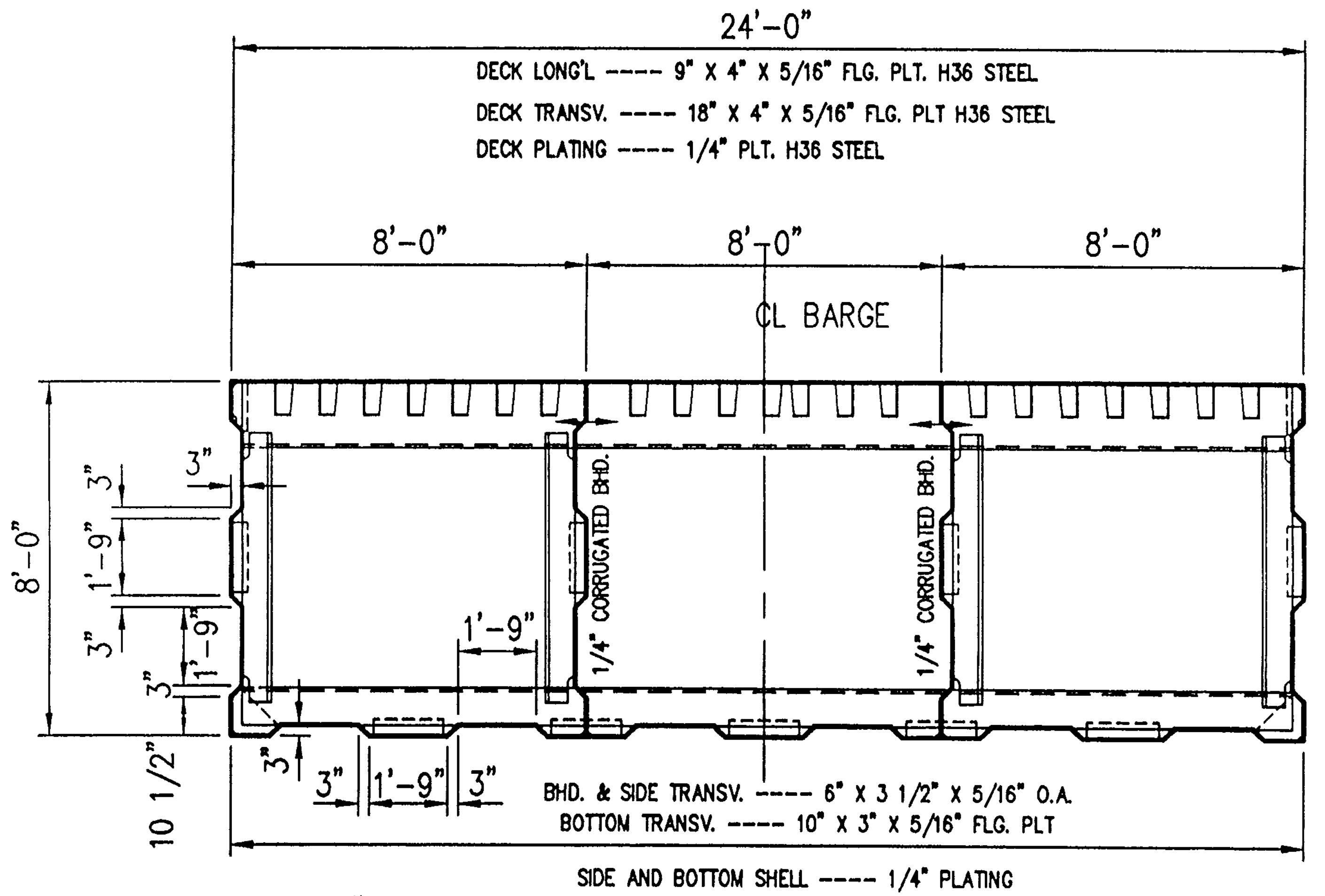
CONCEPT 3

Displacement at 3' freeboard

$$\Delta = \frac{1440}{35} + 5\left(\frac{.75^2\pi}{4}(7+13.2)\right)\Big/35$$

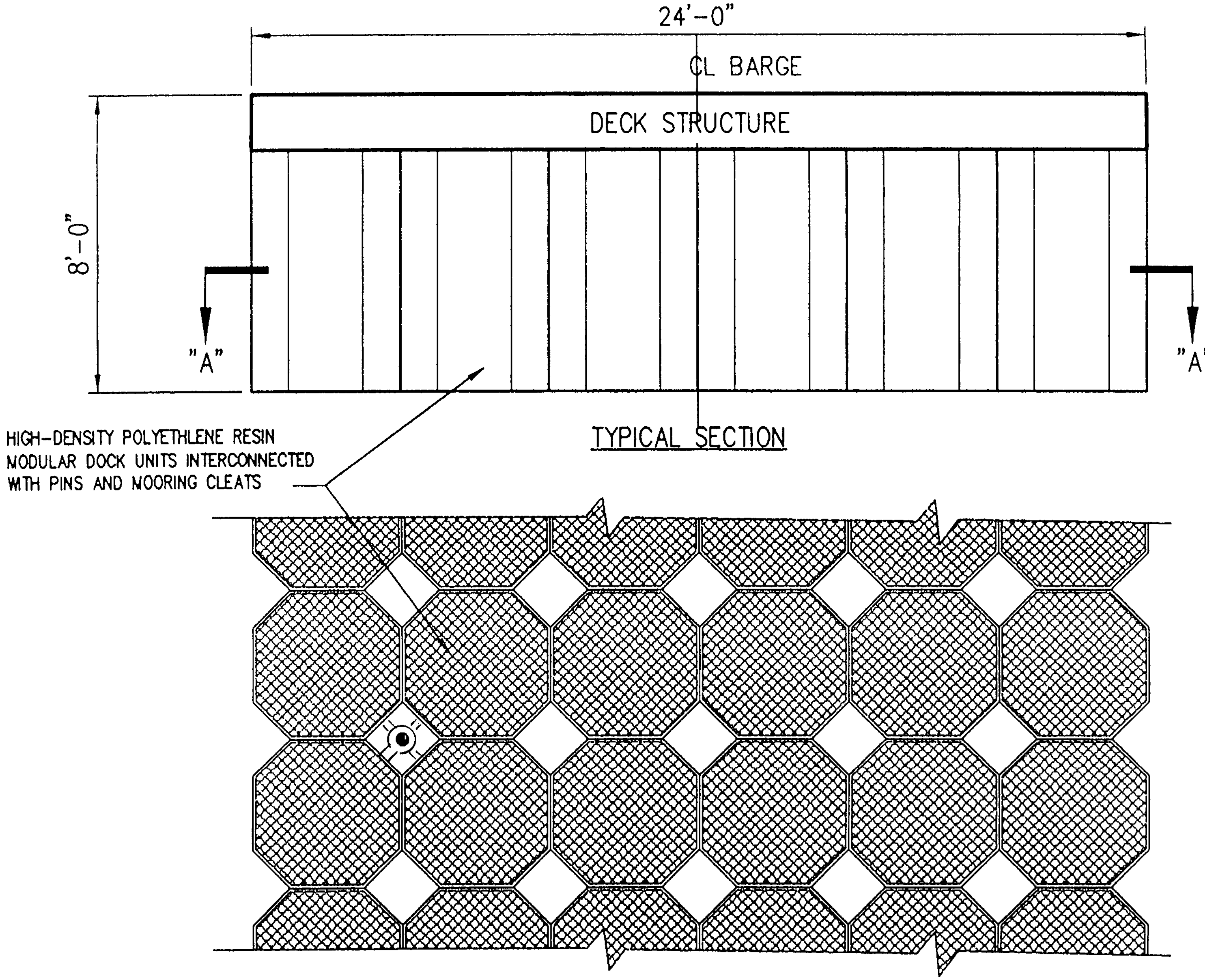
$$= 42.67 \text{ LT}$$

$$C_B = \frac{42.67\,(35)}{(24)(40)(5)} = 0.31$$



TYPICAL TRANSVERSE SECTION

(WITH CORRUGATED SHELL & LONG'L BHD.)



TYPICAL SECTION

PLAN "A"-"A"

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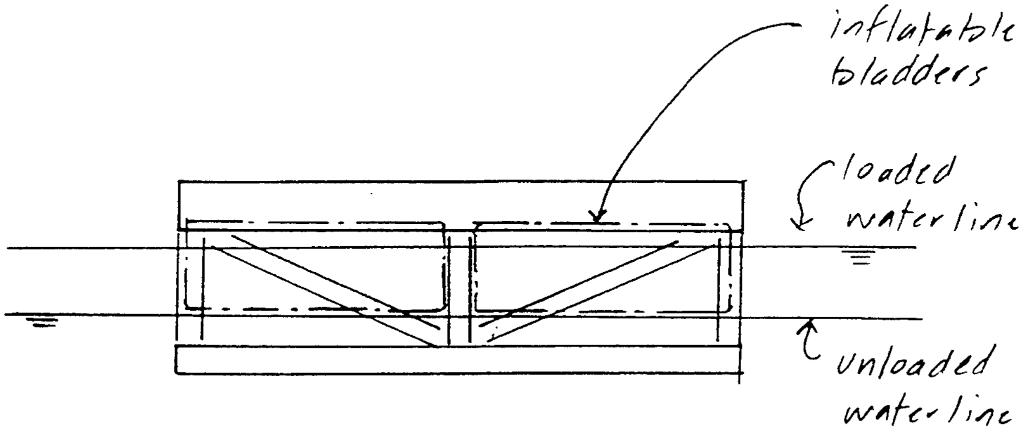
Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of



MODIFIED SEMISUBMERSIBLE

- maintain advantages of semi-submersible during connection procedures
- inflated bladders deployed after connecting allow adequate buoyancy in loaded condition

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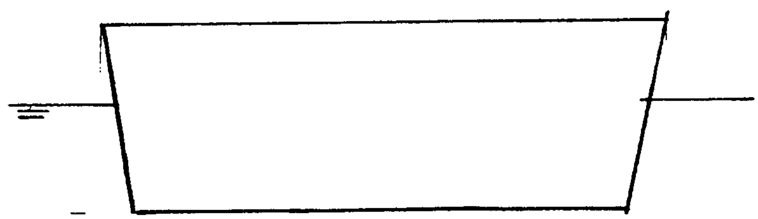
Calculation Sheet

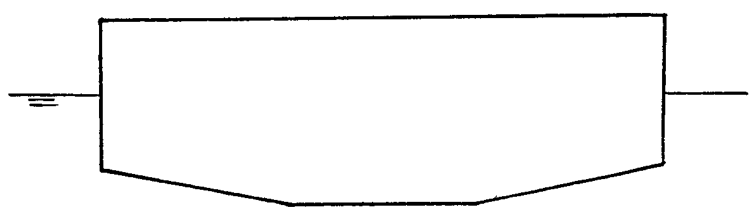
Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject: Sheet of



incorporate flare



incorporate deadrise

SIMPLE HULLFORM MODIFICATIONS

- potential for reduced motions from increased damping

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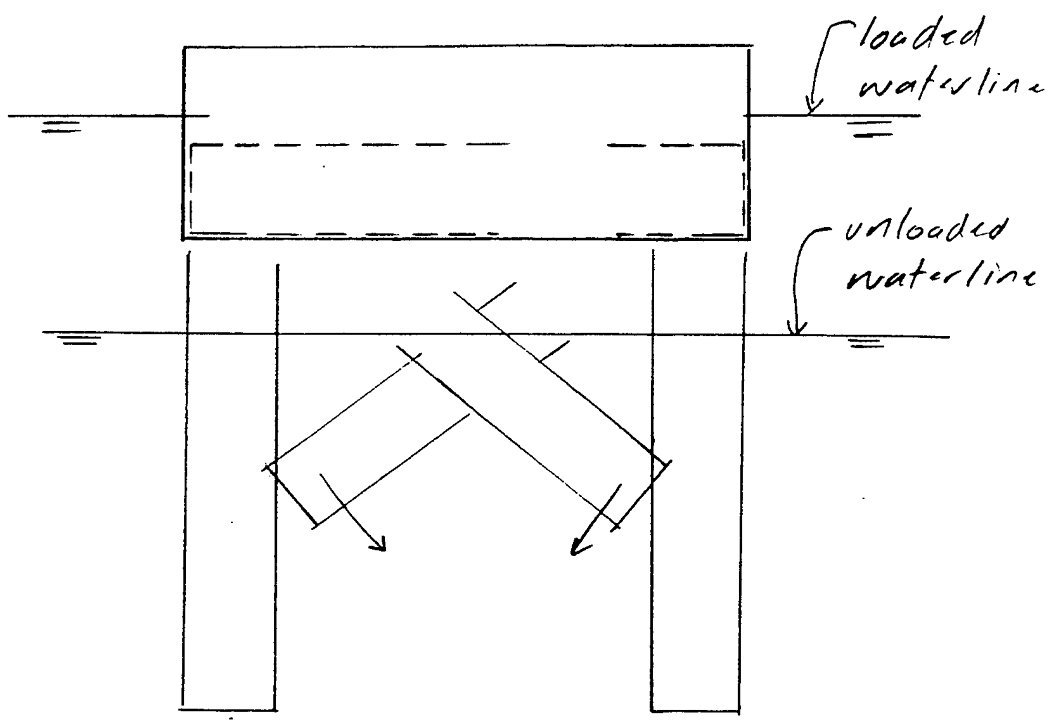
Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject: Sheet of



RETRACTABLE LEGS

- acts as a semi submersible with legs extended – reduced motions

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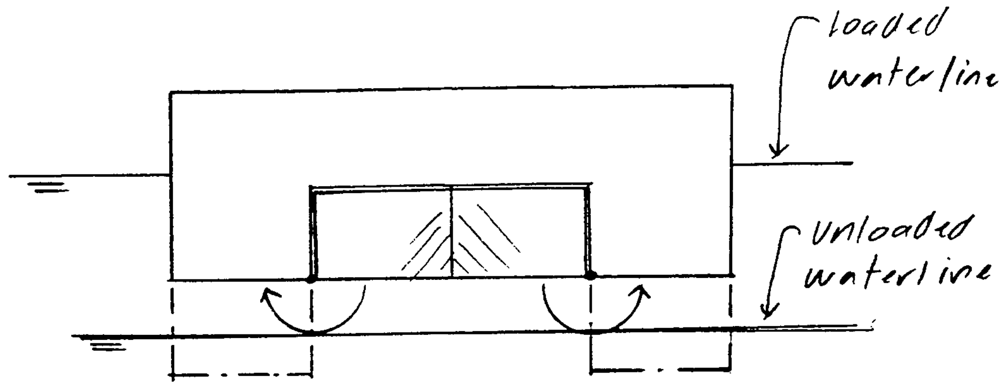
Calculation Sheet

Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject: Sheet of



HINGED HULLFORM

- acts as a catamaran in unloaded condition

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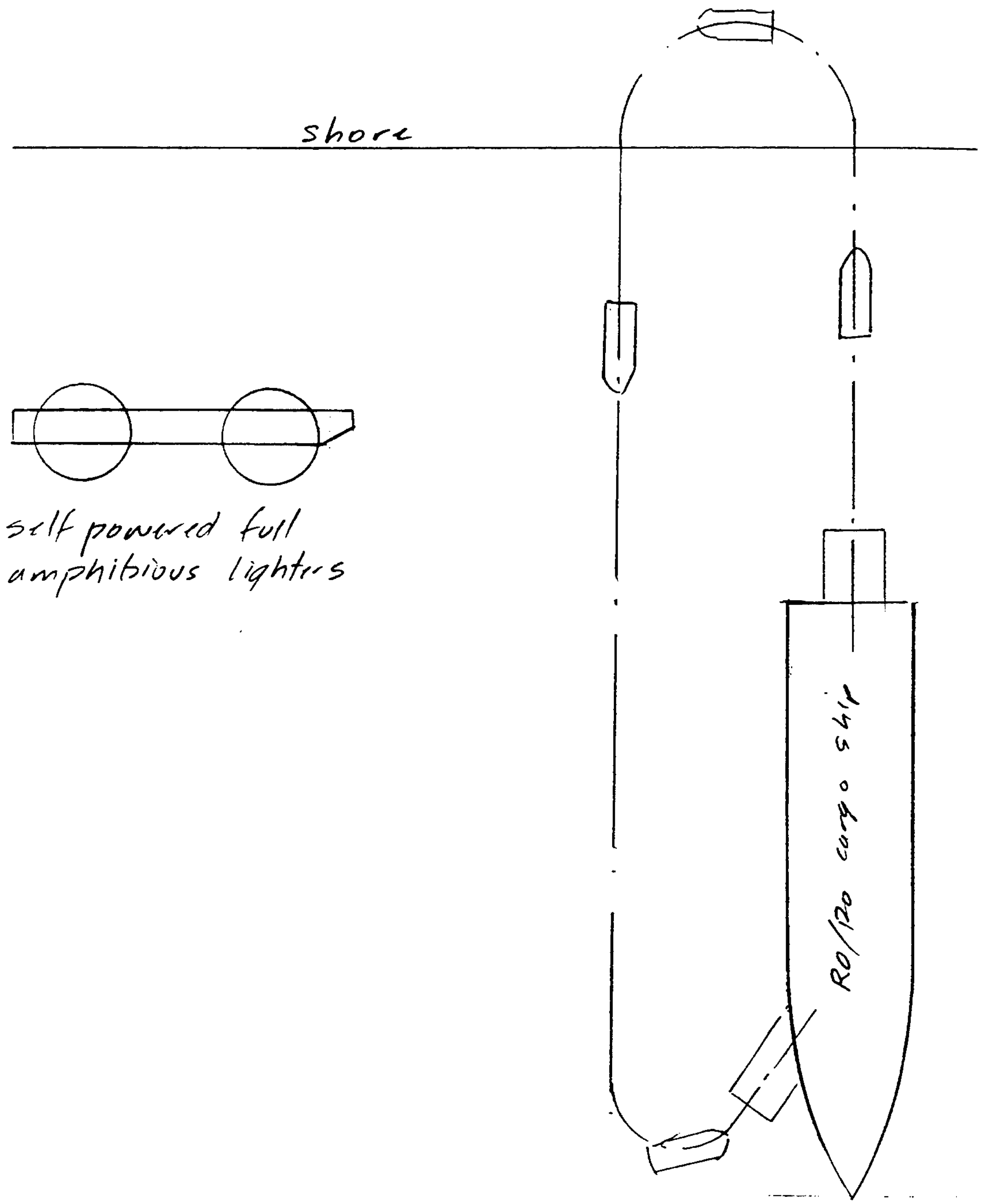
Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of



CONTINUOUS "FLOW THRU" LOADING-UNLOADING

- requires wholesale change of assets

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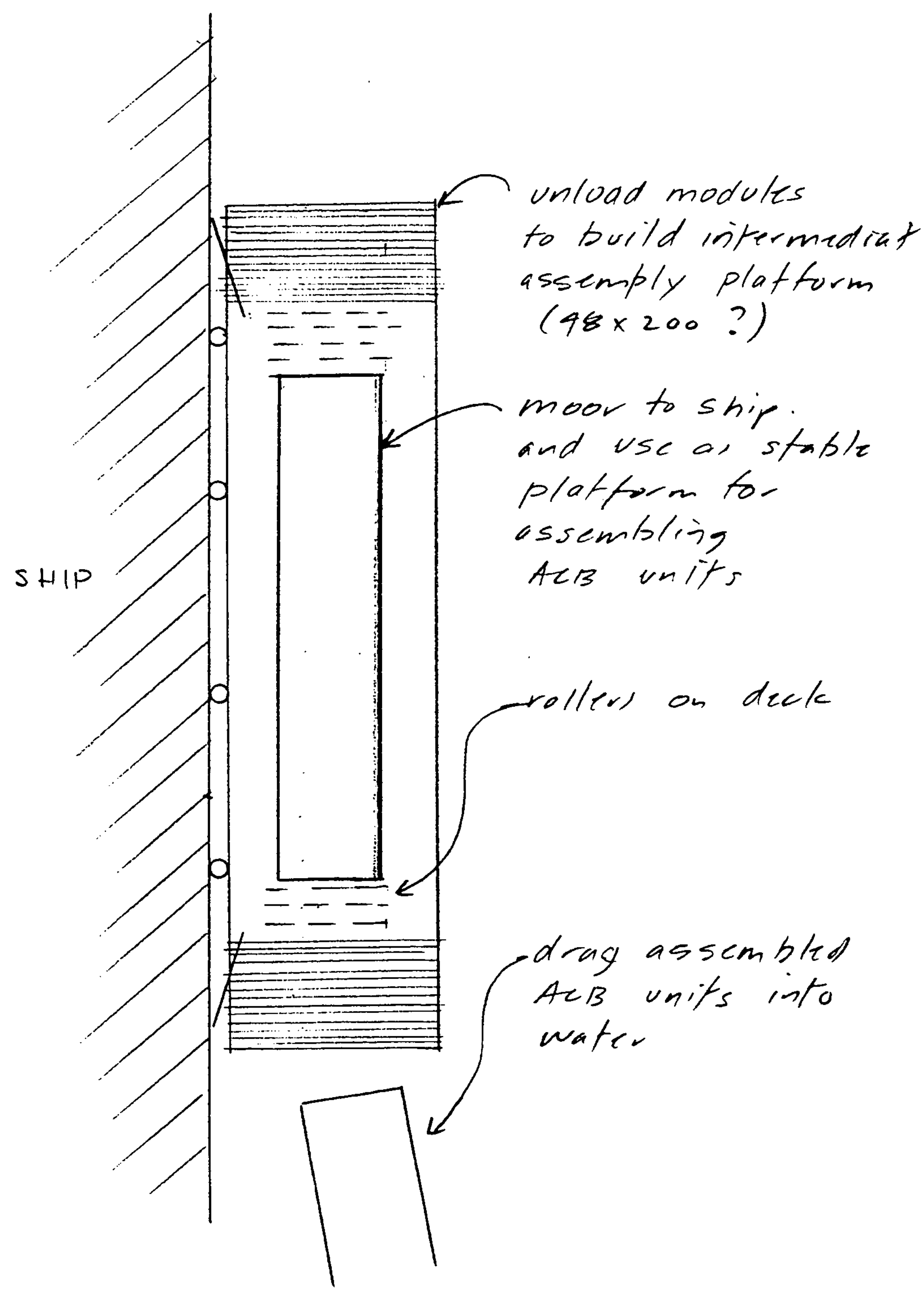
Calculation Sheet

Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject: Sheet of



INTERMEDIATE ASSEMBLY PLATFORM

APPENDIX D

Structural Calculations

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Calculation Sheet

Project No.: 969 | Prepared By: K. NG | Date: 12 SEPT 95

Title: AMPHIBIOUS CARGO BEACHING LIGHTERAGE | Checked By: MD | Date:

Subject: ACB | Sheet of

INITIAL SCANTLINGS

ABS STEEL VESSELS FOR SERVICE ON RIVERS AND INTRACOASTAL WATERWAYS

4.3 SHELL PLATING,

4.3.1. BOTTOM AND SIDE

BOTTOM PLATING $t = 0.000825\,L + 0.007s - 0.019$ in.

$= 0.248''$

$S = 24$ in.
$L = 120$ FT.

$\boxed{\text{USE } 1/4'' \text{ PLATE}}$

SIDE SHELL $t =$ RULE BOTTOM SHELL $- 0.02$ in.
$= 0.228$ in.

$\boxed{\text{USE } 1/4'' \text{ PLATE}}$

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By: M.D	Date:
Subject:		Sheet of

4.13 BULKHEADS

4.13-1 WATERTIGHT BULKHEADS

a. PLATING

TABLE 17-2

$h_1 = 8$ FT.

SPACING OF STIFF'R = 24"

$t = 0.18$

$h = 8$ FT.

USE 3/16" PLATE

b. BHD STIFF'R ON TRANSV. W.T. BHD.

$N = 0.46\,hs$
$= 3.68$

$h = 4$ FT.
$S = 2$ FT
$\ell = 8$ FT.

USE $3'' \times 2'' \times 1/4''$ L FROM TABLE 17-3
$N = 6$

LONG'L BHD STIFF'R

$N = 0.46\,hS$
$= 5.52$

$h = 6$ FT.
$S = 2$ FT
$\ell = 8$ FT

USE $3'' \times 2'' \times 1/4''$ L FROM TABLE 17-3
$N = 6$

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Calculation Sheet

Project No.:	Prepared By:		Date:
Title:	Checked By:	MD	Date:
Subject:			Sheet of

4.15 FRAMING IN HOLDS

4.15.4 SCANTLINGS

a. $N = chs$ FIG. 4.5 DECK BARGE
SCANTLING FROM TABLE 17-3.
Required SM from 1.41.2

BOTTOM TRANSV. $N = 1.00\,hs$ $h = 8$ FT.
$= 64$ $S = 8$ FT.

$\boxed{10'' \times 3 \times 5/16''\ \text{FLG PLT}}$

REQ'D SM $= 0.0041\,N\,l^2\ in^3$
$= 16.79\ in^3$

$SM = 17.55\ in^3$

BOTTOM LONG'L $N = 1.08\,hs$ $h = 8$ FT
$= 17.28$ $S = 2$ FT

$\boxed{\text{USE } 5 \times 3 \times 5/16\ L.}$

SIDE TRANSV. $N = 1.00\,hs$ $h = 4$ FT
$= 32$ $S = 8$ FT

$\boxed{\text{USE } 6 \times 3\tfrac{1}{2} \times 5/16\ L}$

SIDE LONG'L $N = 1.08\,hs$ $h = 6$ FT.
$= 12.96$ $S = 2$ FT.

$\boxed{\text{USE } 4'' \times 3'' \times 1/4''\ L.}$

RAKE FRAMING FIG. 3-11
BOTTOM LONG'L $N = 1.28\,hs$ $h = 8$ FT
$= 20.48$ $S = 2$ FT.

$\boxed{\text{USE } 5 \times 3 \times 5/16\ L}$

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CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Bottom Transverse
FP 10x3x5/16

Date:
Prepared by:

US

Plate thickness	0.25	in
Plate width	32	in
Depth of Section	10	in
Web thickness	0.3125	in
Flange width	3	in
Flange thickness	0.3125	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	8.00	1.00	0.13	0.04
Web	5.09	3.03	15.42	79	23.68
Flange	10.09	0.94	9.46	96	0.01
Totals		11.96	25.88	174	23.73

Centroid	2.16	in
Ixx at centroid	142	in^4
SM pl	65.60	in^3
SM flg	17.55	in^3
Shear Area	3.20	in^2
Iyy		

rx = 3.44 in
ry =

Approximate Weight	
Plate	28.21
Web	10.68
Flange	3.31
W+FLG	13.98

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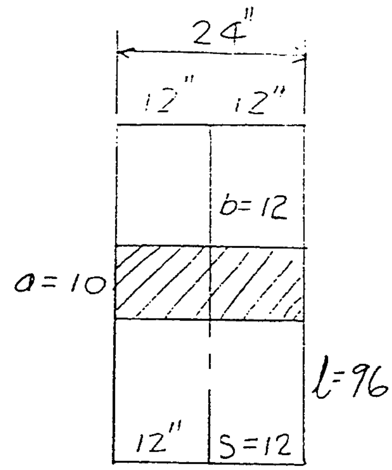
Calculation Sheet

Project No.:	969 ACB	Prepared By:	K. NG	Date:	11 SEPT 95
Title:	DECK PLATING	Checked By:	M.D	Date:	
Subject:	HEAVY CARGO TRUCK			Sheet	of

DECK STRUCTURE Deck Plate

ABS STEEL BARGE RULES 1991

SECTION 6



HEAVY CARGO TRUCK LOAD

COMBINED TIRE PRINT = 10" x 24"

WHEEL LOAD = 16 000 lb.

PANEL LOAD = 16000/2
= 8000 lb.

$t = K K n \sqrt{CW}$ in.
= 0.264 in.

k = 1.0
n = 1.0
l = 96 in.
S = 12 in.
a = 10
b = 12
C = 1.5
W = 3.571 L. Tons.
b/S = 1
a/S = 0.833
K = 0.114
(FIG. 6-1)
ABS

FOR STRENGTH DECK, PLATING TO BE NOT LESS THAN 110% of 't'

$t = 0.264 \times 1.1$
= 0.29 in.

6-19.2 VEHICLE LOADING
DECK PLATE OF HIGHER STRENGTH MATERIAL

$t_{hts} = t_{ms} \sqrt{M/Y}$

= 0.236 in.

t_{ms} = 0.29 in.
M = 34000 PSI
Y = 51000 PSI

USE 1/4" PLATE H36

See Also Deck Design for Permanent Set

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d to avoid the
t be subject to
k plating, etc.
not less than
han obtained

.)
is required by

.17 in.) for ex-

bove equation
$.92/\sqrt{Q}$ in lieu

here the Rules
, the thickness
ed, taking into
l the foregoing

h material and
e' 's having
ti. . obtained

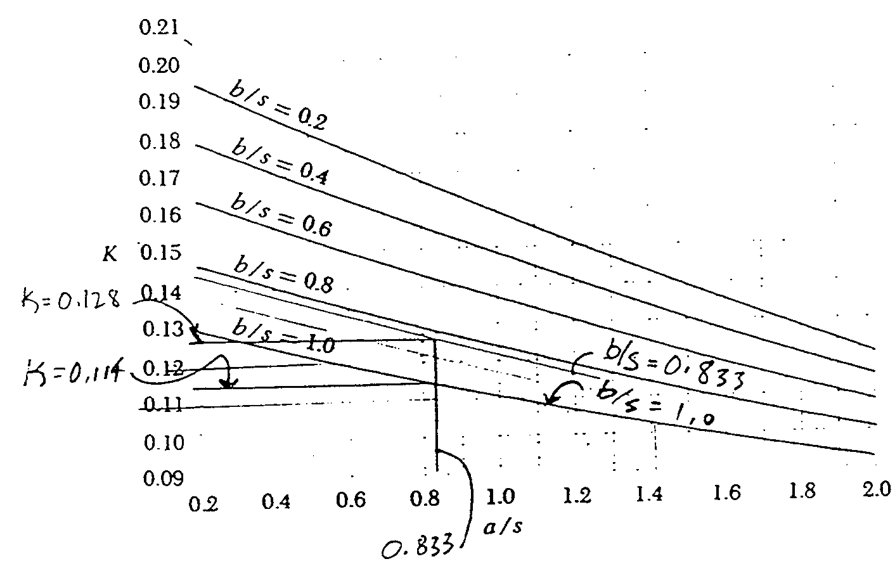
n.)
d from 6.17 in

ı is not destruc-
n the steel by a
ken by the Sur-
which case the
manufacturer's
d with alkaline
deck are to be
wise approved,

6-1

FIGURE ~~16.1~~

Wheel Loading Curves of "K"



holdfasts are to be fitted not more than 915 mm (3 ft) apart. Deck covering within accommodation spaces on the decks forming the crown of machinery and cargo spaces are to be of a type which will not ignite readily.

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Calculation Sheet

Project No.: 969 ACB	Prepared By: K NG	Date: 25 SEPT 95	
Title: DECK LONG'L	Checked By: MD	Date:	
Subject: CARGO HANDLING TRUCK (RCTH)		Sheet 1 of 2	

DECK STRUCTURE – Deck Beams

STIFF'R SPACING = 12"

STIFF'R SPAN = 96"

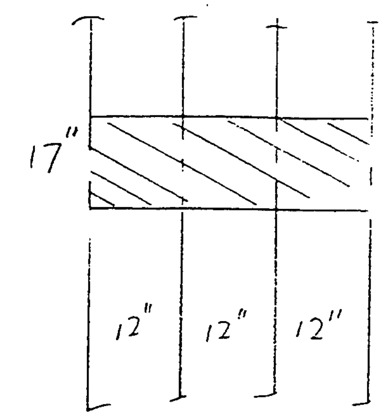
WHEEL LOAD - 75000 lb.

LOAD ON ONE STIFF'R = $\frac{75000}{3}$

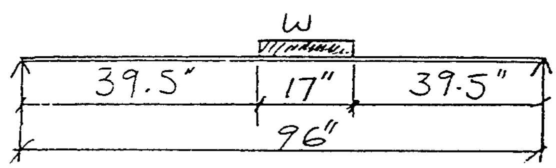
= 25,000 lb.

DIST. LOAD, W = $\frac{25000}{17}$ lb/in.

= 1471 lb/in.



LOAD SHARED BY 3 - DK LONG'L



SIMPLE BEAM

MAX. BM = 546.9 KIPS IN. (FROM STRESSPAC PROGRAM)

ALLOWABLE BENDING STRESS, H36 STEEL USE 2/3 YIELD

YIELD = 51,000 lb/in²

= 2/3 × 51000

= 34 KIPS/in²

REQ'D SM = 546.9/34

= 16.08 in³.

USE

9" x 4" x 5/16" H36 FLG. PLT. WITH 12" x 1/4" H36 PLT.

SM = 16.22 in³.

See Also check of structure for 24" beam spacing

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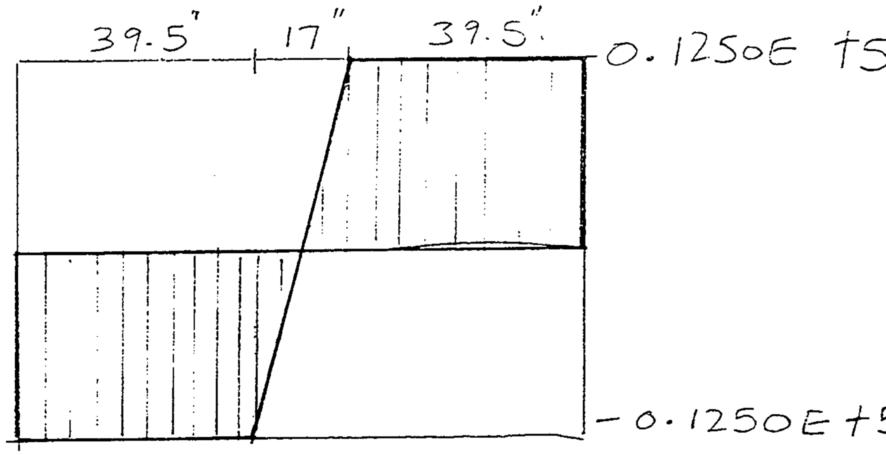
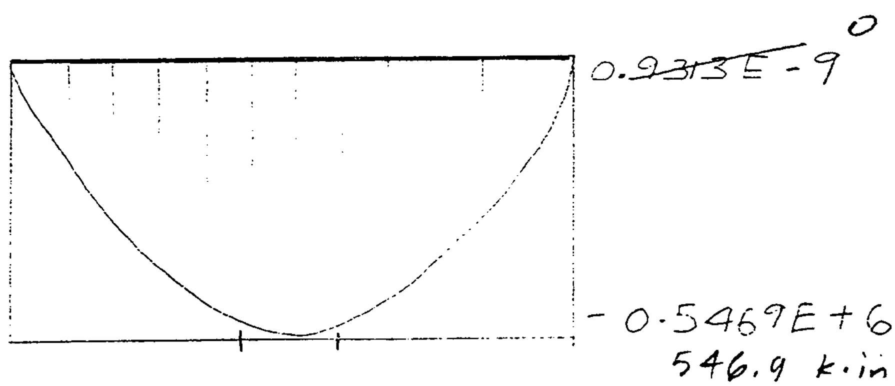
Calculation Sheet

Project No.: 969 ACB	Prepared By:		Date:
Title: DECK LONG'L	Checked By:	MD	Date:
Subject: CARGO HANDLING TRUCK RTCH			Sheet 2 of 2



SHEAR DIAGRAM.



BENDING MOMENT DIAGRAM

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Deck Beam - 12" spacing
FP 9x4x5/16

Date:
Prepared by:

US

Plate thickness	0.25	in
Plate width	12	in
Depth of Section	9	in
Web thickness	0.3125	in
Flange width	4	in
Flange thickness	0.3125	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	3.00	0.38	0.05	0.02
Web	4.59	2.71	12.47	57	17.07
Flange	9.09	1.25	11.37	103	0.01
Totals		6.96	24.21	161	17.10

		Centroid	3.48	in
		Ixx at centroid	94	in^4
		SM pl	26.93	in^3
rx =	3.67 in	SM flg	16.22	in^3
ry =		Shear Area	2.89	in^2
		Iyy		

Approximate Weight	
Plate	10.58
Web	9.57
Flange	4.41
W+FLG	13.98

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Calculation Sheet

Project No.: 969 ACB Prepared By: K. NG Date: 25 SEPT 95

Title: DECK TRANSV. Checked By: Date:

Subject: CARGO HANDLING TRUCK Sheet 1 of 2

DECK STRUCTURE — Web Frame Transverses

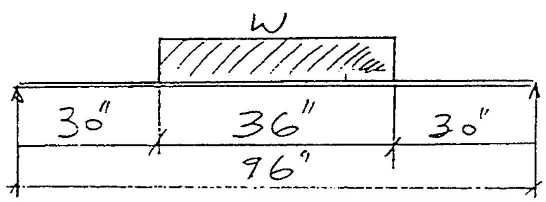
TRANSV. SPAN = 96"

COMBINED WHEEL LOAD = 75000 lb

TIRE PRINT = 36" x 17"

DIST. LOAD, w = $\frac{75000}{36}$

w = 2083 lb/in.



SIMPLE BEAM

MAX. B.M = 1462 KIPS IN (STRESSPAC PROGRAM)

ALLOWABLE BENDING STRESS, H36 STEEL USE 2/3 YIELD

YIELD STRENGTH = 51,000 lb/in^2

= 2/3 x 51000

= 34 KIPS/in^2

REQ'D SM = 1462 / 34

= 43 in^3

(H36)

18" x 4" x 5/16" FLG PLT WITH 32" DK PLATE, 1/4" H36

SM = 48.39 in^3

USE 18" x 4" x 5/16" FLG PLT, 2 TIMES DEPTH OF DK LONG'L

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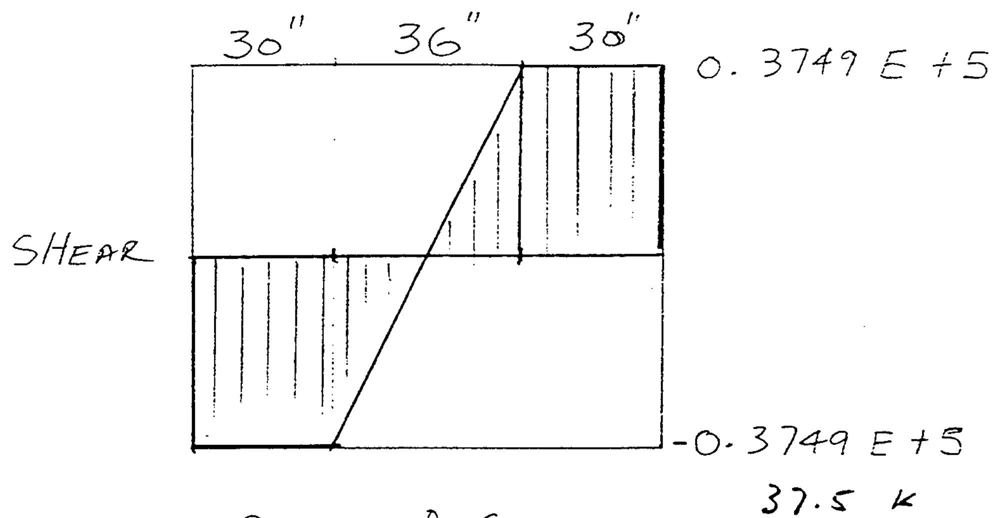
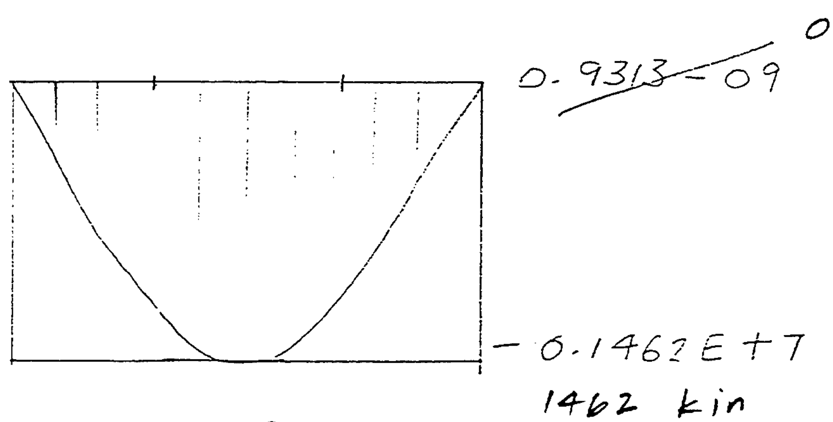
Calculation Sheet

Project No.: 969 ACB	Prepared By: K. NG	Date: 25 SEPT 95	
Title: DECK TRANSV.	Checked By:	Date:	
Subject: CARGO HANDLING TRUCK		Sheet 2 of 2	



SHEAR DIAGRAM



MOMENT DIAGRAM

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Web Frame Transverses
FP 18x4x5/16

Date:
Prepared by:

US

Plate thickness	0.25	in
Plate width	32	in
Depth of Section	18	in
Web thickness	0.3125	in
Flange width	4	in
Flange thickness	0.3125	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	8.00	1.00	0.13	0.04
Web	9.09	5.53	50.26	457	144.10
Flange	18.09	1.25	22.62	409	0.01
Totals		14.78	73.88	866	144.15

		Centroid	5.00	in
		Ixx at centroid	641	in^4
		SM pl	128.25	in^3
rx =	6.59 in	SM flg	48.39	in^3
ry =		Shear Area	5.70	in^2
		Iyy		

Approximate Weight	
Plate	28.21
Web	19.49
Flange	4.41
W+FLG	23.90

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Calculation Sheet

Project No.: 969	Prepared By: MD	Date:	
Title: ACB Lighter	Checked By:	Date:	
Subject: Structure		Sheet	of

SUMMARY OF INITIAL SCANTLINGS

- Shell, bulkheads, shell and bulkhead stiffeners, side and bottom transverses to ABS River Rules
- Deck Plate to ABS Steel Barge Rules under Heavy Cargo Truck (semi trailer) with dynamics considered, no yield.
- Deck beams, web frame transverses, — direct calculation under RTCH load no dynamics considered.

Deck Plate	1/4"	H36
Deck Beams	FP 9 x 4 x 5/16	H32
Deck Transv.	FP 18 x 4 x 5/16	H36
Side Shell	1/4"	
Side Longitudinal	L 4 x 3 x 1/4	
Side Transverse	L 6 x 3½ x 5/16 Rule Use 8 x 4 x 7/16 due to depth of side longitudinal	
Bottom Shell	1/4"	
Bottom Longitudinal	L 5 x 3 x 5/16	
Bottom Transverse	FP 10 x 3 x 5/16	
Bulkhead plate	1/4"	
Bulkhead Stiff.	L 3 x 2 x 1/4"	

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Calculation Sheet

Project No.:	969	Prepared By:	M. D.	Date:	
Title:	ACB Lighter	Checked By:		Date:	
Subject:	STRUCTURE — Deck Structure			Sheet	1 of 8

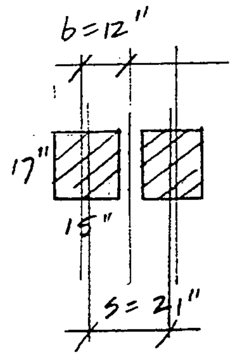
Deck Plate

Estimation of Permanent Set Using Design Curves

Reference: Hughes, O. F., "Ship Structural Design", SNAME, 1988, pp 355-360

For Deck stiffener Spacing 12"

RTCH Wheel Load



Load P total = 75^k
Wheel Patch per Sealift con Cargo Handling Truck

Twin wheel load — Selection of Load width c

$$\lambda = \frac{s+d}{b} \qquad s = 21'' \quad d = 15'' \quad b = 12''$$

$$\lambda = \frac{21+15}{12} = 3 \geq 1$$

$\therefore$ consider single wheel only
$\therefore$ $c = 15''$

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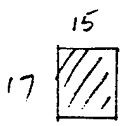
Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet 2 of 8



$P = 37.5^{k}$

$e = 15''$

$f = 17''$

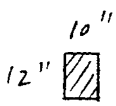
$\therefore \quad e_m = \sqrt{ef} = \sqrt{(15)(17)} = 15.97''$

$b/e_m = 12/15.97 = 0.75$

$\therefore$ This size of wheel patch places the load condition outside of the design curves

Assume that the same load is carried on a smaller wheel patch $\longrightarrow$ give an upper bound on permanent set

Use



$P = 37.5^{k}$

$e = 10''$

$f = 12''$

$e_m = \sqrt{(10)(12)} = 10.9$

$b/e_m = 12/10.9 = 1.10$ $\quad\therefore$ This patch size with design curve parameters

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Plate slenderness parameter β.

$$\beta = \frac{b}{t}\sqrt{\frac{\sigma_y}{E}}$$

$b = 12''$
$t = 0.25''$
$\sigma_y = 51$ ksi
$E = 30 \times 10^3$ ksi

$$\therefore \quad \beta = \frac{12}{0.25}\sqrt{\frac{51}{30 \times 10^3}} = 1.98$$

$$Q_{p_1} = \frac{PE}{(b\,\sigma_y)^2} = \frac{(37.5)(30 \times 10^3)}{((12)(51))^2} = 3.00$$

From Design Curve for $\frac{W_p}{\beta t} = 0.2$

$$Q_{p_2}\Big|_{\substack{\beta = 1.98 \\ b/\ell_m = 1.10}} = 3.0 \qquad \underline{\underline{\text{Match}}}$$

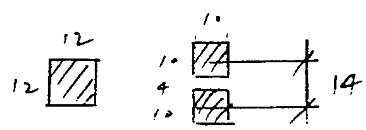
$\therefore$ For this smaller wheel patch $W_p/\beta t = 0.2$

or $W_p = (0.2)\beta t = (0.2)(1.98)(0.25) = 0.099''$

$\therefore$ <u>For actual wheel patch $W_p < 0.099''$</u>

<u>What is the level of Permanent Set if stiffener spacing is 24"</u>

<u>Heavy Cargo Truck</u>



Per Sealift COR

10^k 16^k

Front Tractor Bogie

<u>Front</u> $P = (1.5)(10) = 15^k$ including dynamic factor

$e = 12''$

$f = 12''$

$\therefore \ell_m = 12''$

$b/\ell_m = 24/12 = 2.00$

$\beta = \frac{24}{0.25}\sqrt{\frac{51}{30\times10^3}} = 3.96$

$Q_{p_1} = (15)(30\times10^3)/((24)(51))^2 = 0.300$

From design curve for $W_p/\beta t = 0.2$

$Q_{p_2}\Big|_{\beta=3.96,\ b/\ell_m=2} \cong 0.48 > 0.300$

$\therefore$ at $Q_p = 0.3$ $W_p/\beta t << 0.2$

$\therefore W_p << (0.2)(3.96)(0.25) = 0.198$ in

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Calculation Sheet

Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject: Sheet 5 of 8

<u>Tractor Bogie</u> $P = (1.5)(8) = 12^k$ including dynamic

Twin wheel load - selection of load width

$$\lambda = \frac{s+d}{b} = \frac{14+10}{12} = 1.0$$

∴ consider as single wheel only, $e = 10''$

∴ $e = 10''$
$f = 10''$
$e_m = 10''$

$b/e_m = 24/10 = 2.4$

$\beta = 3.96$

$Q_{p_1} = (12)(30 \times 10^3) / ((24)(51))^2 = 0.240$

From design curve for $W_p/\beta t = 0.2$

$$Q_{p_2}\Big|_{\substack{\beta = 3.96 \\ b/e_m = 2.4}} = 0.42 > 0.240$$

∴ at $Q_p = 0.24$ $W_p/\beta t \ll 0.2$

∴ $W_p \ll (0.2)(3.96)(0.25) = 0.198$ in

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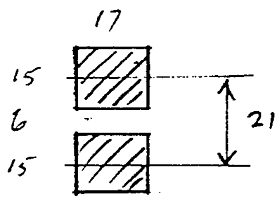
Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject:

RTCH



Per Scaliff COR

$\lambda = \frac{s+d}{b} = \frac{21+15}{24} = 1.5 \geq 1$ ∴ treat as single wheel, $e = 15''$

$e = 15''$

$f = 17''$

$c_m = 15.97''$

$b/c_m = 24/15.97 = 1.5$

$\beta = 3.96$

$Q_{P_1} = (37.5)(30\times10^3) / ((24)(51))^2 = 0.75$

From Design Curve for $W_P/\beta t = 0.2$ $(W_P = 0.198)$

$Q_{P_2}\Big|_{\beta=3.96,\ b/c_m=1.5} \cong 0.63 < 0.75$

From Design Curve for $W_P/\beta t = 0.4$ $(W_P = 0.396)$

$Q_{P_2} \cong 0.84 > 0.75$

∴ $0.198'' < W_P < 0.396''$

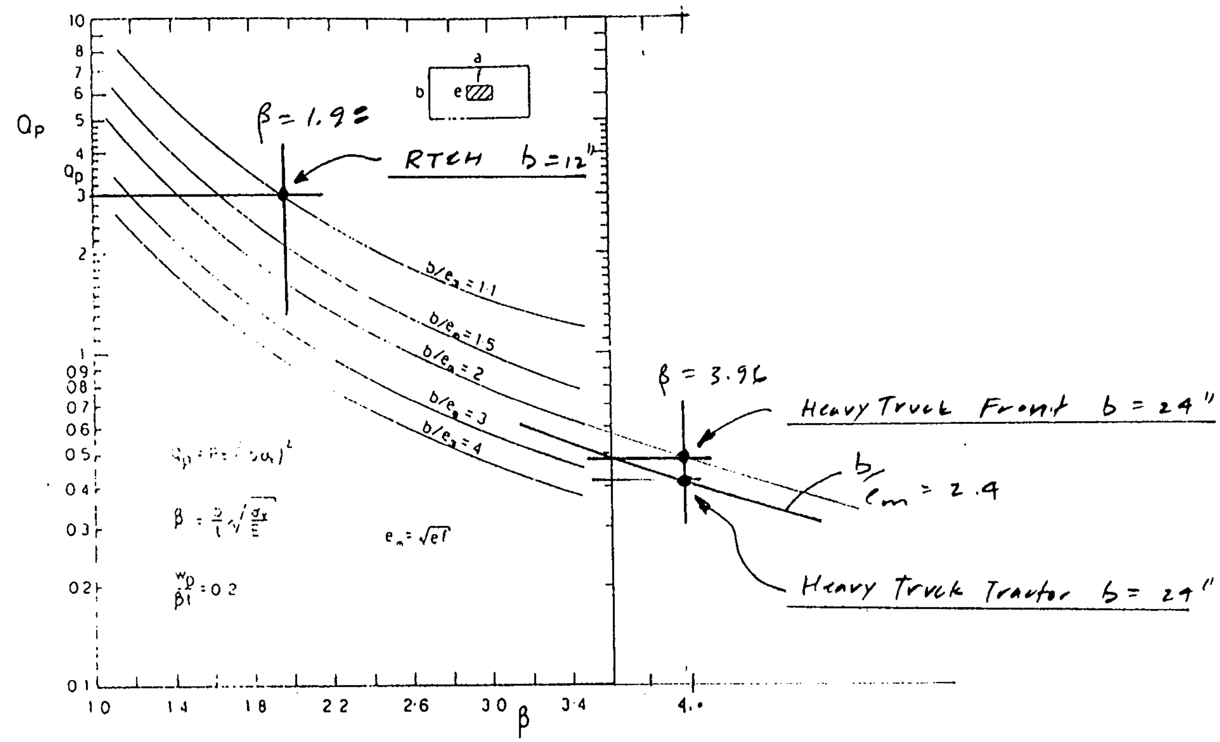


Figure 9.25a Design curves for single location concentrated loads.

Design Curves for Permanent Set - Hughes "Ship Structural Design" p 360

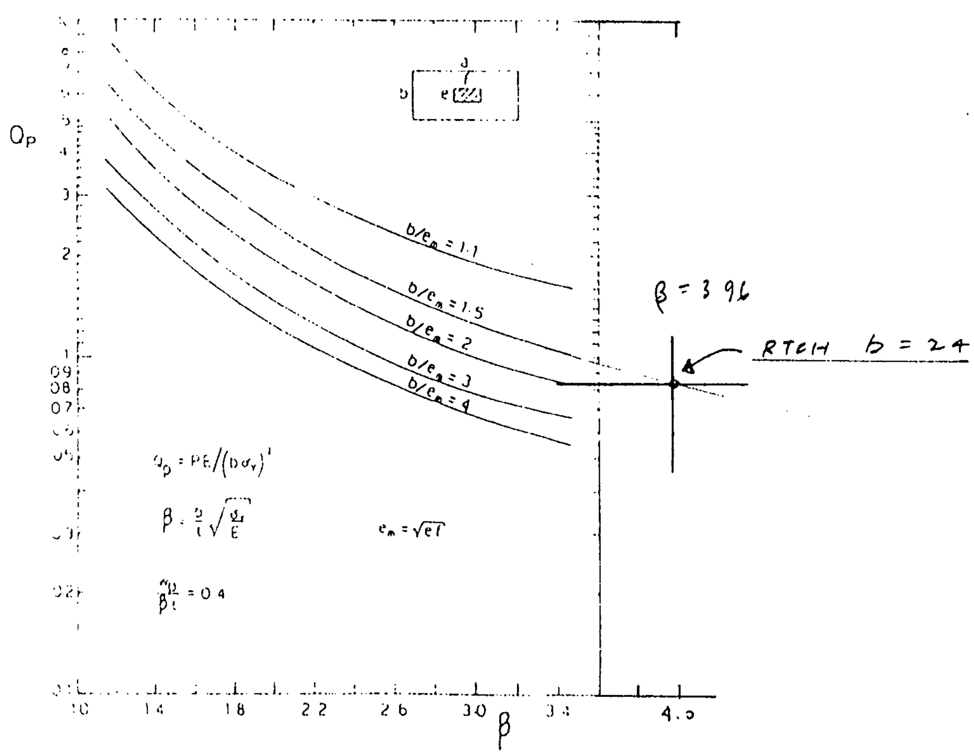


Figure 9.25b Design curves for single location concentrated loads

Design Curves for Permanent Set - Hughes "Ship Structural Design" p 360

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Title: Checked By: Date:

Subject: Sheet of

DECK PLATE — Summary

With 1/4" high strength steel deck plate

- For 12" deck beam spacing
  - Under Heavy Cargo Truck Wheel load

    9000# on 10" x 10" patch

    → no permanent set (per ABS)

  - Under RTCH Wheel Load

    37500# on 15" x 17" patch

    → permanent set < 1/8"

- For 24" deck beam spacing
  - Under Heavy Cargo Truck Wheel load

    → permanent set << 3/16"

  - Under RTCH Wheel Load

    → permanent set between 3/16" and 3/8"

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Title: Checked By: Date:

Subject: Sheet of

These estimates of the amount of permanent set are conservative for the following reasons:

- Analysis method per Hughes is estimate to cummulative permanent set over time with wheel load in any orientation

  ACB mission will likely see RTCH load more with RTCH longitudinally oriented which is the better case

- Wheel patch dimensions are from Sealift COR which are conservatively small

The level of maximum permanent set using this conservative analysis ($\approx \frac{1}{4}$" under RTCH) is in itself reasonable.

∴ Adoption of 24" beam spacing is feasible.

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Calculation Sheet

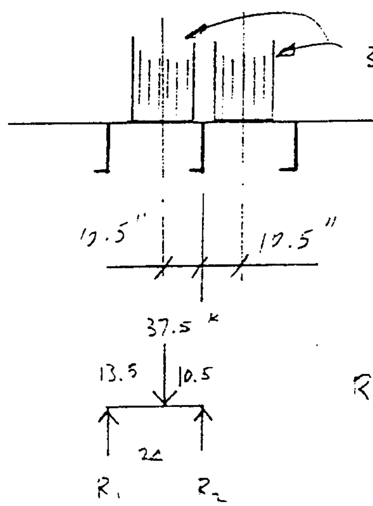
Project No.: 967	Prepared By: M. D.	Date:	
Title: ACB Lighter	Checked By:	Date:	
Subject: STRUCTURE		Sheet 1 of 5	

Deck Supporting structure

Check Effects of 24" beam spacing on beam size

RTCH Load with RTCH oriented longitudinally

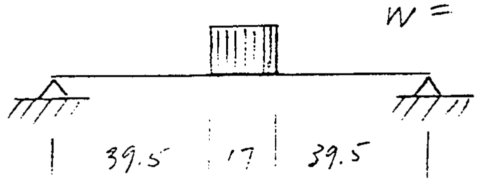
37.5^k wheel loads

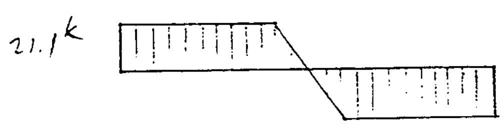


$$R_2 = \frac{(37.5)(13.5)}{24} = 21.1^k$$

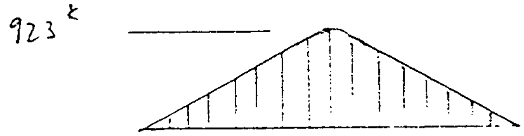
∴ total load per longitudinal $(21.1)(2) = 42.2^k$

$$w = {}^{42.2}/_{17} = 2.432\ {}^k/_{in}$$





shear



moment

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet 2 of 5

Section Required

$$SM_{req} = \frac{M}{\sigma_{all}}$$

$$\sigma_{all} = (.67)(51) = 34.17 \text{ ksi}$$

$$\therefore \quad SM_{req} = \frac{923}{34.17} = 27 \text{ in}^3$$

Provide FP $15 \times 4 \times \frac{1}{4}$

$SM = 27.04 \text{ in}^3$
$wt \cong 16 \#/ft$

This section should be sufficient since the simply supported end condition is conservative

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CALCULATION OF SECTION PROPERTIES

ACB Lighter Development
Project No. 969

Date: 30-Oct-95
Prepared by: Mark Dabell

Deck Longitudinals 24 in spacing
FP 15x4x1/4

US FP

Plate thickness	0.25 in
Plate width	24 in
Depth of Section	15 in
Web thickness	0.25 in
Flange width	4 in
Flange thickness	0.25 in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	6.00	0.75	0.09	0.03
Web	7.50	3.63	27.19	204	63.51
Flange	15.13	0.88	13.23	200	0.01
Totals		10.50	41.17	404	63.55

Centroid	3.92 in
Ixx at centroid	306 in^4
SM pl	78.11 in^3
SM flg	27.04 in^3
Shear Area	3.81 in^2
Iyy	

rx = 5.40 in
ry =

Approximate Weight	
Plate	21.16
Web	12.78
Flange	3.09
W+FLG	15.87

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet 4 of 5

<u>Effects of 24" beam spacing on Deck trans.</u>

Maximum moment on Transverse

$1462^{k \cdot in}$ (see ABS calculations)

$SM_{req} = 43 \text{ in}^3$

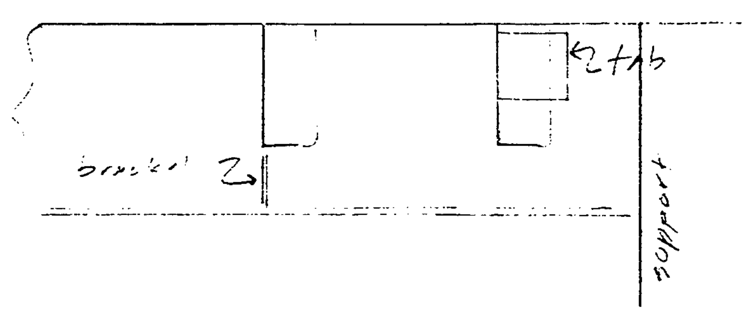
With deeper deck beams must provide deeper transverse

∴ Provide FP $24 \times 4 \times \frac{1}{4}$

$SM = 58.11 \text{ in}^3$

$Wt \cong 25 \text{ \#/ft}$

Since this section is not twice the depth of the deck beams, must provide brackets at each beam without tabs. Provide tabs at beam closest to support



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5/5

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Deck Transverses
FP 24x4x1/4

Date: 30-Oct-95
Prepared by: Mark Dabell

US FP

Plate thickness	0.25	in
Plate width	32	in
Depth of Section	24	in
Web thickness	0.25	in
Flange width	4	in
Flange thickness	0.25	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	8.00	1.00	0.13	0.04
Web	12.00	5.88	70.50	846	270.37
Flange	24.13	0.88	21.11	509	0.01
Totals		14.75	92.61	1355	270.42

Centroid	6.28	in
Ixx at centroid	1044	in^4
SM pl	166.33	in^3
SM flg	58.11	in^3
Shear Area	6.06	in^2
Iyy		

rx = 8.41 in
ry =

Approximate Weight	
Plate	28.21
Web	20.72
Flange	3.09
W+FLG	23.80

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Calculation Sheet

Project No.:	969	Prepared By:	M.D	Date:	
Title:	ACB Lighter	Checked By:		Date:	
Subject:	STRUCTURE			Sheet	of

OPTIONS FOR STRUCTURAL ARRANGEMENTS

Review following options for structure for weight trade-offs:

- ordinary strength steel for deck
- transverse framing
- corrugated panels to replace stiffeners on shell and bulkheads
- 4 ft web frame spacing

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Review of Ordinary Strength Steel for Deck

$\sigma_{all} = (34)(0.67) = 22.8$

For 12" deck beam spacing

Deck Plate

From ABS calculations

$t = 0.29$ in   Provide 5/16"

Deck Beams

$M_{max} = 546.9$ k in

$SM_{req} = \frac{546.9}{22.8} = 23.9$ in^3

Provide FP 12×5×5/16

SM = 25 in^3

wt ≅ 19 #/ft

Deck Transverses

$M_{max} = 1462$ k in

$SM_{req} = 1462/22.8 = 64$ in^3

Provide FP 24×5×5/16

SM = 65 in^3

wt ≅ 30# /ft

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CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Deck Beams OS Steel
FP 12x5x5/16

Date:
Prepared by:

US FP

Plate thickness	0.3125	in
Plate width	12	in
Depth of Section	12	in
Web thickness	0.3125	in
Flange width	5	in
Flange thickness	0.3125	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.16	3.75	0.59	0.09	0.03
Web	6.00	3.55	21.33	128	38.33
Flange	12.16	1.37	16.62	202	0.01
Totals		8.67	38.53	330	38.37

		Centroid	4.44	in
		Ixx at centroid	197	in^4
		SM pl	44.39	in^3
rx =	4.77 in	SM flg	25.07	in^3
ry =		Shear Area	3.85	in^2
		Iyy		

Approximate Weight	
Plate	13.22
Web	12.54
Flange	4.82
W+FLG	17.36

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. .969

Deck Transverses OS Steel
FP 24x5x5/16

Date:
Prepared by:

US FP

Plate thickness	0.3125	in
Plate width	12	in
Depth of Section	24	in
Web thickness	0.3125	in
Flange width	5	in
Flange thickness	0.3125	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.16	3.75	0.59	0.09	0.03
Web	12.00	7.30	87.66	1052	332.60
Flange	24.16	1.37	33.03	798	0.01
Totals		12.42	121.27	1850	332.64

Centroid	9.76	in
Ixx at centroid	999	in^4
SM pl	102.28	in^3
SM flg	68.63	in^3
Shear Area	7.60	in^2
Iyy		

rx = 8.97 in
ry =

Approximate Weight	
Plate	13.22
Web	25.76
Flange	4.82
W+FLG	30.58

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Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Review Transvers Framing

24 in Frame Spacing
ordinary strength steel $\sigma_{all} = 22.3$ ksi

Deck Plate

$$t = \{k K_n \sqrt{c W}\} 1.1$$

$k = 1$
$n = 1$
$c = 1.1$
$W = 7,143$ LT Heavy Cargo Track

$K \cong 0.124$

$t = 0.44$ in Provide $\frac{7}{16}$"

Deck Beams

$M_{max} = 1462$

$SM_{req} = 1462/22.3 = 64$ in^3

Provide F [illegible]
[illegible]
[illegible]

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Calculation Sheet

Project No.: 969 ACB Prepared By: K. NG Date: 26 SEPT 1995

Title: CORRUGATED BARGE CONSTR. Checked By: Date:

Subject: LONGITUDINAL BHD & SIDE SHELL Sheet 1 of 2

Review Corrugated Bulkheads and shell

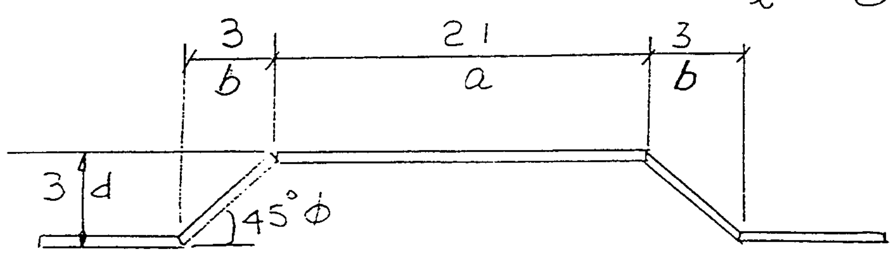
4.13 BULKHEADS. (ABS RIVERS & INTRACOASTAL)
LONG'L W.T. BHD

4.13-1 b. STIFF'R

$SM = 0.0041 N l^2 \; in^3$
$= 1.45 \; in^3$

$N = 0.46hs$
$= 5.52$
$h = 6$
$s = 2$
$l^2 = 8^2$

($= 3.23 \; in^3$ STEEL BARGE RULE)



$t = 0.25$
$a = 3''$
$b = 21$
SPACING $= (a + b) = 24''$

9.5.4 (STEEL BARGE RULES)
CORRUGATED BHD.

DEVELOPED SECTION MODULUS

$SM = (td^2/6) + (adt/2) \; in^3$
$= \underline{8.25 \; in^3}$

$SM = 6.1875 \; in^3$

$t = 3/16''$

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Calculation Sheet

Project No.:	Prepared By: K. NG	Date: 26 SEPT 95	
Title: CORRUGATED BARGE CONSTR.	Checked By:	Date:	
Subject: BOTTOM SHELL		Sheet 2 of 2	

4.15.4 SCANTLINGS.

BOTTOM LONG'L

$$SM = 0.0041\, N \ell^2 \text{ in}^3$$
$$= \underline{4.534 \text{ in}^3.}$$

$N = 1.08\, hS$
$= 17.28$
$h = 8$ FT.
$S = 2$ FT.
$\ell^2 = 8^2$

USE SAME CORRUGATION AS LONG'L W.T. BHD.
1/4" PL.

$$\underline{SM = 8.25 \text{ in}^3.}$$

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Review 4 ft Web Frame Spacing

High Strength Steel Deck $\sigma_{all} = 34$ ksi
longitudinal framing
12" beam spacing

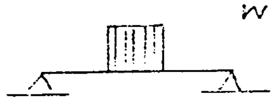
Deck Plate

As before

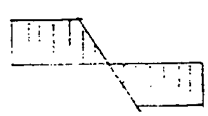
Provide 1/4"

Deck Beams

$w = 75/3 / 17 = 1.471$ k/in



15.5 17 15.5

12.5 k  shear

247 k-in  moment

$SM_{req} = \frac{247}{34} = 7.26$ in^3

Provide L 6x3½x5/16
SM = 8.7
wt = 9.8 #/ft

Deck Transv.

$SM_{req} = 43$ in^3

Provide FP 12 x 5 x 3/8
SM = 46 in^3
wt ≅ 26 #/ft

CALCULATION OF SECTION PROPERTIES

ACB Lighter Development
Project No. 969

Deck Longitudinals
L6x31/2x5/16

Date: 30-Oct-95
Prepared by: Mark Dabell

US

Plate thickness	0.25	in
Plate width	12	in
Depth of Shape	6	in
Area of Shape	2.87	in^2
Centroid of Shape	3.99	in
Inertia of Shape	10.9	in^4

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	3.00	0.38	0.05	0.02
Shape	4.24	2.87	12.17	51.60	10.90
Totals		5.87	12.54	51.64	10.92

		Centroid	2.14 in
		Ixx at centroid	35.75 in^4
		SM pl	16.73 in^3
rx	2.47	SM flg	8.69 in^3
ry	2.49	Shear Area	2.87 in^2
		Iyy	36.39 in^4

Approximate Weight

Plate	10.58
Shape	10.12

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Date:
Prepared by:

Deck Transverses
FP 16 x5x3/8

US FP

Plate thickness	0.25 in
Plate width	32 in
Depth of Section	16 in
Web thickness	0.375 in
Flange width	5 in
Flange thickness	0.375 in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	8.00	1.00	0.13	0.04
Web	7.88	5.72	45.04	355	110.83
Flange	16.06	1.59	25.60	411	0.02
Totals		15.31	71.63	766	110.89

Centroid	4.68 in
Ixx at centroid	542 in^4
SM pl	115.80 in^3
SM flg	46.82 in^3
Shear Area	6.09 in^2
Iyy	

rx = 5.95 in
ry =

Approximate Weight	
Plate	28.21
Web	20.17
Flange	5.62
W+FLG	25.79

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Calculation Sheet

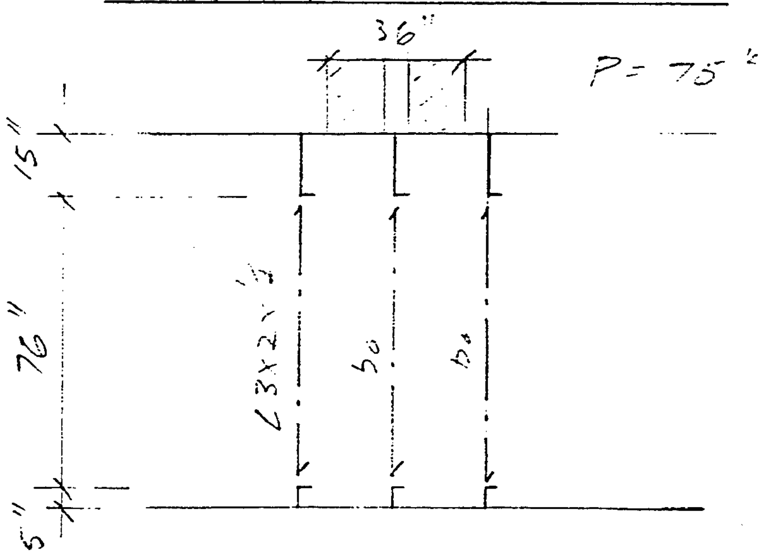
Project No.:	969	Prepared By:	M. D	Date:	
Title:	ACB Lighter	Checked By:		Date:	
Subject:	STRUCTURE			Sheet	of

<u>CHECK ACB STRUCTURE UNDER OPERATIONAL LOADING</u>

<u>Check Transverse Bulkhead Under RTCH</u>

Ref: DDS 100-4 "Strength of Structural Members" 1992

<u>Plate / stiffener as a Column</u>



Assume central plate/stiffener carries 60% of total load as a column

$P = (75)(0.6) = 45^k$

Effective breadth of attached plate

$\min\{60t, L_u/3\} = \min\{[illegible], 76/3\} = \underline{15 \text{ in}}$

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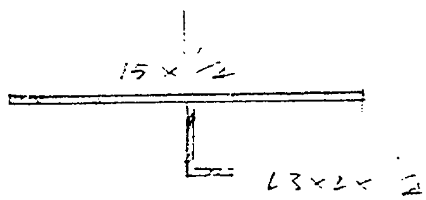
Title:	Checked By:	Date:
Subject:		Sheet of



$A = 4.94 \text{ in}^2$

$r \cong 1.03 \text{ in}$

Compressive Stress $= \sigma = 45/4.94 = \underline{9.11 \text{ ksi}}$

Critical Buckling Stress =

$$\sigma_{cr} = \left(\frac{F_c}{F_y}\right) F_y$$

F_c/F_y from Fig 1 DDS 100-4

Buckling factor $\lambda = k \frac{L_b}{r} \sqrt{\frac{F_y}{E}}$

$$= (1)\left(\frac{76}{1.03}\right)\sqrt{\frac{34}{30\times10^3}} = 2.48$$

$\therefore \; F_c/F_y = 0.82$

$\therefore \; \sigma_{cr} = F_c = (0.82)(34) = \underline{27.88 \text{ ksi}}$

$\underline{\sigma < \sigma_{cr} \; \therefore \text{ plate/stiff stable}}$

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CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Transv BHD plate/stiff.
L 3.2.1/4

Date:
Prepared by:

US L

Plate thickness	0.25	in
Plate width	15	in
Depth of Section	3	in
Web thickness	0.25	in
Flange width	2	in
Flange thickness	0.25	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	3.75	0.47	0.06	0.02
Web	1.63	0.69	1.12	2	0.43
Flange	3.13	0.50	1.56	5	0.00
Totals		4.94	3.15	7	0.46

		Centroid	0.64 in
		Ixx at centroid	5 in^4
		SM pl	8.16 in^3
rx =	1.03 in	SM flg	1.99 in^3
ry =		Shear Area	0.81 in^2
		Iyy	

Approximate Weight	
Plate	13.22
Web	2.42
Flange	1.76
W+FLG	4.19

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Check proportions for tripping of flanges

Flange-to-depth ratio $b_f/d = 2/3 = 0.67$

L_u/b_f maximum from Fig 3A DDS 100-4

$L_u/b_f = 34$

$\therefore L_u \text{ max} = (34)(2) = 68''$

$\therefore$ must either increase stiffener or provide tripping bracket

Try $4 \times 3 \times \frac{1}{4}$ $\quad b_f/d = \frac{3}{4} = 0.75, \quad L_u/b_f = 34+$

$\therefore L_u \text{ max} = (34)(3) = 102 \quad$ ok

Flange proportion

$$b_f/t \leq \frac{1}{\sqrt{F_y/E}}$$

$$b_f/t = 2/0.25 = 8 \qquad L\ 3 \times 2 \times \tfrac{1}{4}$$
$$3/.25 = 12 \qquad L\ 4 \times 3 \times \tfrac{1}{4}$$

$$\frac{1}{\sqrt{\frac{F_y}{E}}} = \frac{1}{\left(\frac{34}{30 \times 10^3}\right)^{1/2}} = 29$$

$\therefore$ either section is ok

$\therefore$ Provide $L\ 4 \times 3 \times \frac{1}{4}$ or fit tripping brackets

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Calculation Sheet

Project No.:	Prepared By:	Date:	
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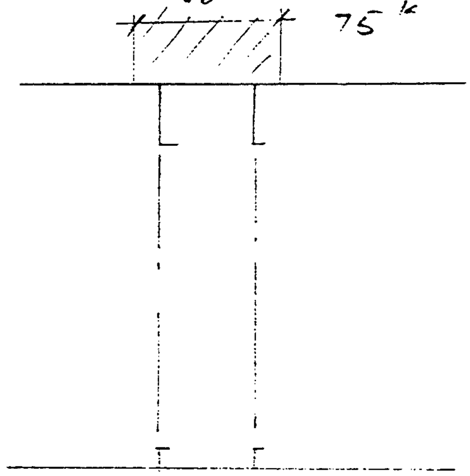
Plate alone under Load



Assume 24" panel carries entire load (conservative)

Compressive stress; $\sigma = 75/(24)(0.25) = 12.5^{ksi}$

Plate Buckling factor; $\beta = \frac{b}{t}\sqrt{\frac{F_y}{E}} = \frac{24}{0.25}\sqrt{\frac{34}{30\times10^3}} = 3.23$

F_u/F_y from Fig 4 DDS 100-4

$$F_u/F_y\Big|_{\beta = 3.23} = 0.58$$

$\therefore \quad F_u = (0.58)(34) = 19.72$

$\sigma < F_u$ $\therefore$ Plate panel is stable

$\therefore$ Transverse Bulkhead Structure is sufficient

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
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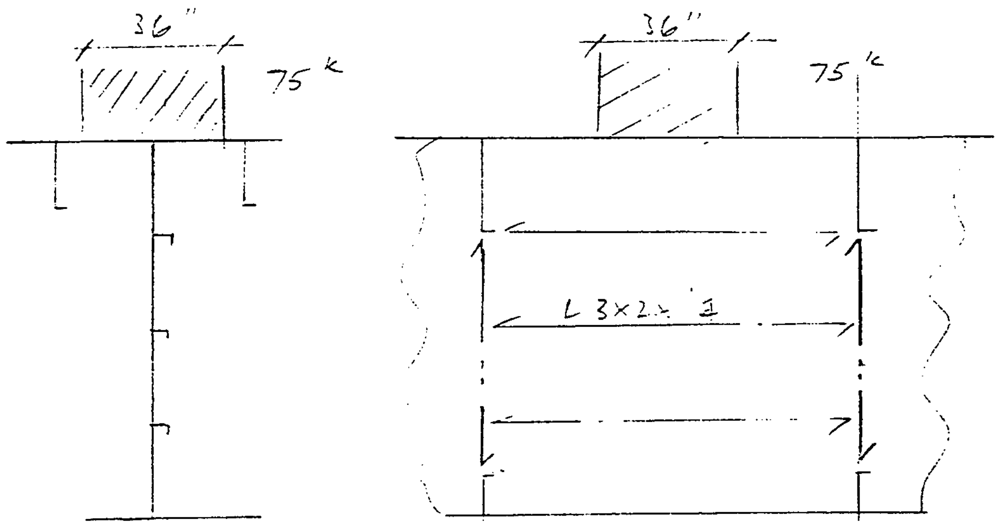
Check Longitudinal Bulkhead under RTCH

Ref DDS 100-4 "Strength of Structural Members" 1982



longitudinal orientation

transverse orientation

For longitudinal orientation load is carried by adjacent beams

Transverse orientation worst case

Local Buckling

Assume entire load carried by 36" wide panel

Compressive stress $\sigma = 75/(36)(.25) = 8.33$ ksi

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Plate Buckling factor $B = \frac{b}{t}\sqrt{\frac{F_y}{E}} = \frac{36}{0.25}\sqrt{\frac{34}{30\times10^3}} = 4.85$

F_u/F_y from Fig 4 DDS 100-4

$F_u/F_y = 0.41$

$\therefore F_u = (0.41)(34) = 13.95$ ksi

$\sigma < F_u$ ∴ plate does not buckle locally.

Full Panel Buckling

For simplicity, assume full load is carried on panel width somewhere in depth of barge

$\therefore \sigma = 75/(96)(0.25) = 3.125$ ksi

Plate ratio $b/a = 24/96 = 0.25$

K_p from Fig 7 DDS 100-4

$K_p\Big|_{b/a=0.25} = 1.87$

Plate Buckling Factor $B = \frac{24}{0.25}\sqrt{\frac{34}{30\times10^3}} = 3.23$

$K_p B = (1.87)(3.23) = 6.04$

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

F_u/F_y from Fig 5 DDS 100-4

$$F_u/F_y \Big|_{k_p B = 6.04} = 0.1$$

$\therefore F_u = (0.1)(34) = 3.4$ ksi

$\sigma < F_u \therefore$ panel is stable

$\therefore$ Longitudinal Bulkhead structure is sufficient

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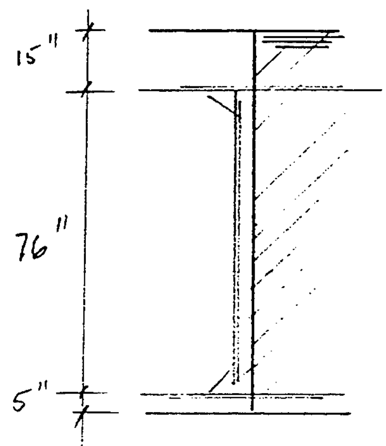
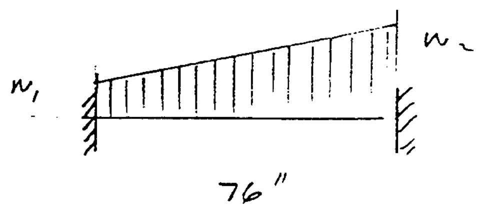
Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

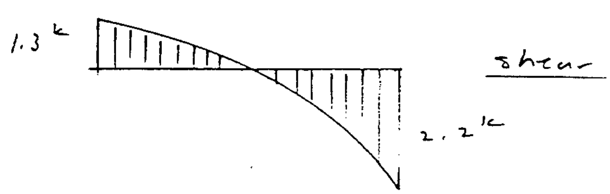
Check Transverse Bulkhead against Flooding Loads

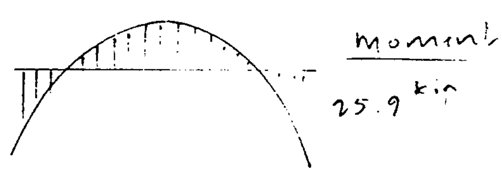


$$w_1 = s\gamma h = (24)(64)(1.25)/144$$
$$= 13.33\ \#/in$$
$$= 0.0133\ ^k/in$$



$$w_2 = s\gamma h = (24)(64)(7.58)/144$$
$$= 80.85\ \#/in$$
$$= 0.081\ ^k/in$$





$$SM_{req} = \frac{25.9}{22.8} = 1.14\ in^3$$

$\angle 3 \times 2 \times \frac{1}{4}$ provided $SM = 1.79.$ ok

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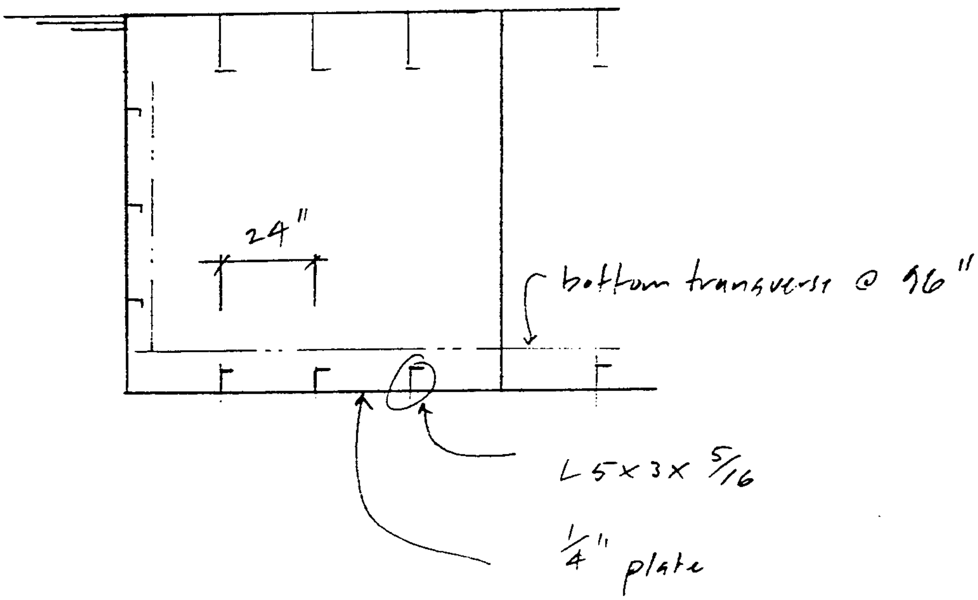
Calculation Sheet

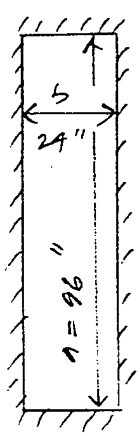
Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Check Bottom Shell to Hydrostatic Loads



Check bottom shell assuming waterline at deck edge

Bottom Shell Plate



full fixed on four sides
uniform pressure p

$$p = \gamma h$$

$$= \frac{64^{\#}}{\cancel{ft^3}} \times 8\cancel{ft} \times \frac{\cancel{ft^2}}{144\ in^2} = 3.56\ psi$$

$$= 0.00356\ ksi$$

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
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Ref: "Roark's Formula for Stress and Strain" 1989
p 464, Table 26

$$\sigma_{max} = \frac{\beta_1 q b^2}{t^2} \qquad y_{max} = \frac{\alpha q b^4}{E t^3}$$

for $a/b = 96/24 = 4$; $\beta_1 \cong 0.498$, $\alpha \cong 0.028$

$$\therefore \sigma_{max} = \frac{(0.498)(0.00356)(24^2)}{0.25^2} = \underline{16.34 \text{ ksi}}$$

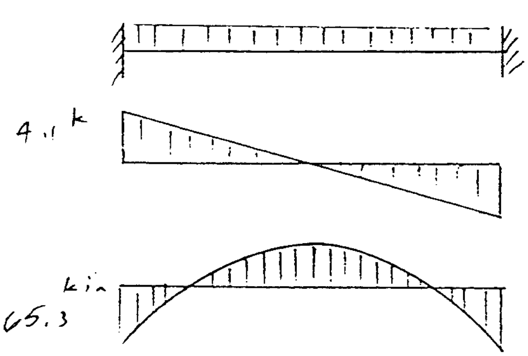
$$y_{max} = \frac{(0.028)(0.00356)(24)^4}{(30\times10^3)(0.25)^3} = \underline{0.07 \text{ in}}$$

$\therefore$ plate still in small deflection region

$\underline{\sigma = 16.34 < \sigma_{all} = 22.8 \quad \therefore \tfrac{1}{4}'' \text{ plate ok}}$

<u>Bottom Longitudinals</u>

$w = (0.00356)(24) = 0.085$ k/in



$$SM_{req} = \frac{65.3}{22.8} = 2.86 \text{ in}^3$$

Provided $L\,5\times3\times\frac{5}{16}$

$\underline{SM = 6.44 \quad ok}$

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Date:
Prepared by:

Bottom Longitudinals
L 5x3x5/16

US L

Plate thickness	0.25	in
Plate width	24	in
Depth of Section	5	in
Web thickness	0.3125	in
Flange width	3	in
Flange thickness	0.3125	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	6.00	0.75	0.09	0.03
Web	2.59	1.46	3.80	10	2.68
Flange	5.09	0.94	4.78	24	0.01
Totals		8.40	9.32	34	2.72

Centroid	1.11	in
Ixx at centroid	27	in^4
SM pl	24.01	in^3
SM flg	6.44	in^3
Shear Area	1.64	in^2
Iyy		

rx = 1.78 in
ry =

Approximate Weight	
Plate	21.16
Web	5.17
Flange	3.31
W+FLG	8.47

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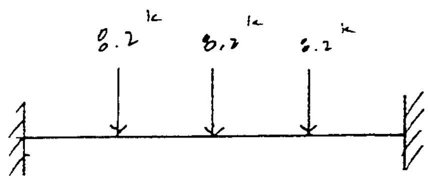
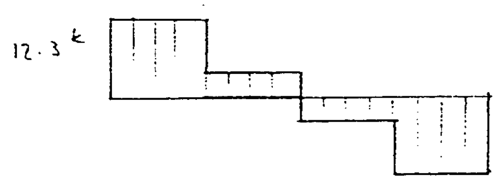
Calculation Sheet

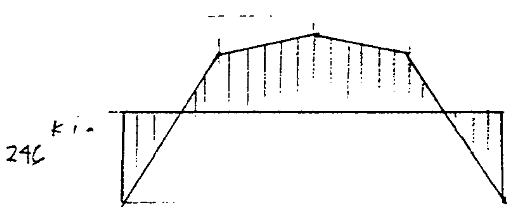
Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Bottom Transverses





shear



moment

$$SM_{req} = \frac{246}{22.3} = 10.8 \text{ in}^3$$

Provided FB 10 x 3 x 5/16

$SM = 14.9 \text{ in}^3$ OK

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Bottom Transverses
FP 10x3x5/16

Date:
Prepared by:

US FP

Plate thickness	0.25	in
Plate width	32	in
Depth of Section	10	in
Web thickness	0.3125	in
Flange width	3	in
Flange thickness	0.3125	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	8.00	1.00	0.13	0.04
Web	4.94	2.93	14.47	71	21.46
Flange	10.09	0.74	7.49	76	0.01
Totals		11.67	22.96	147	21.51

Centroid	1.97 in
Ixx at centroid	124 in^4
SM pl	62.80 in^3
SM flg	14.91 in^3
Shear Area	3.20 in^2
Iyy	

rx = 3.25 in
ry =

Approximate Weight	
Plate	28.21
Web	10.33
Flange	2.62
W+FLG	12.95

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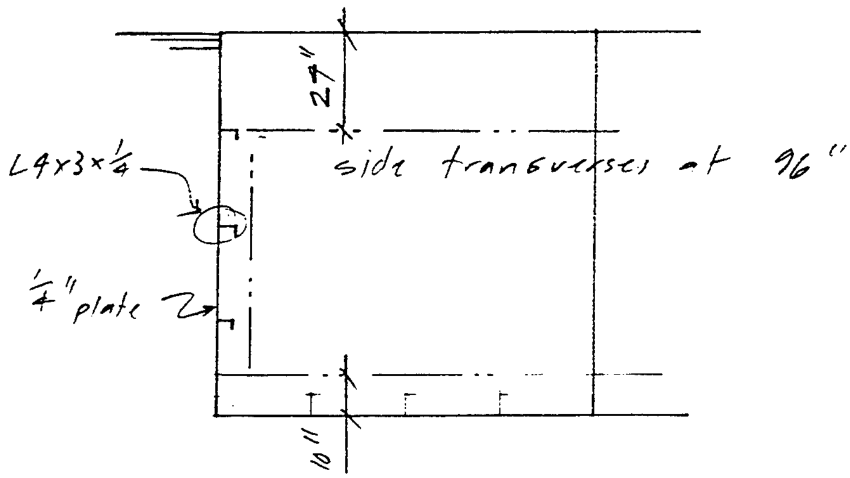
Calculation Sheet

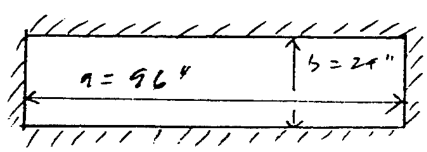
Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Check Side Shell to Hydrostatic Loads



Check side shell assuming waterline at deck edge

Side Shell Plate



uniform pressure for deepest strake

$$p = \gamma h$$

$$= \frac{(64)(8)}{144} = 3.56 \text{ psi} = 0.00356 \text{ ksi}$$

Per bottom shell analysis 1/4" plate is ok

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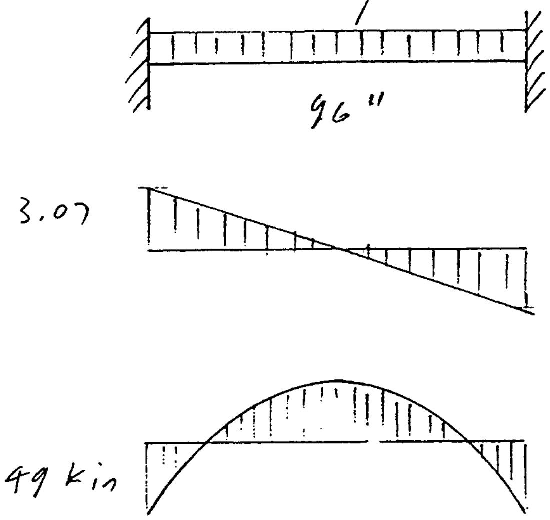
Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Side Longitudinals

$$w = s\gamma h = \frac{(24)(64)(6)}{(1000)(144)} = 0.064\ ^{k}/_{in}$$



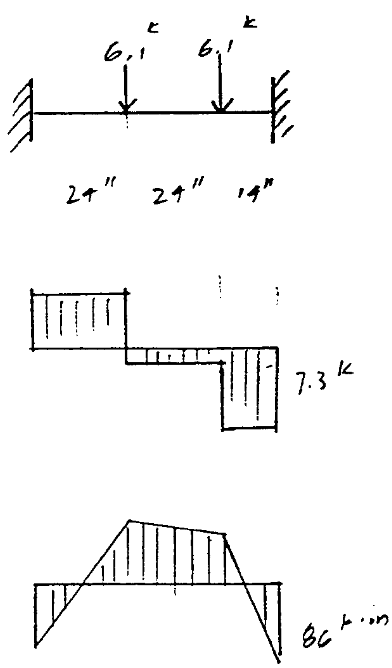
for lowest longitudinal

$$SM_{req} = \frac{49}{22.3} = 2.156\ in^3$$

Provided $L\ 4 \times 3 \times \frac{1}{4}$

$SM = 3.95\ in^3$ ok

Side Transverses



$$SM_{req} = {}^{86}/_{22.8} = 3.77\ in^3$$

Provided $L\ 8 \times 4 \times {}^{7}/_{16}$

$SM = 19.9\ in^3$ OK

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Side Longitudinals
L 4x3x1/4

Date:
Prepared by:

US L

Plate thickness	0.25	in
Plate width	24	in
Depth of Section	4	in
Web thickness	0.25	in
Flange width	3	in
Flange thickness	0.25	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	6.00	0.75	0.09	0.03
Web	2.13	0.94	1.99	4	1.10
Flange	4.13	0.75	3.09	13	0.00
Totals		7.69	5.84	17	1.13

Centroid	0.76	in
Ixx at centroid	14	in^4
SM pl	18.17	in^3
SM flg	3.95	in^3
Shear Area	1.06	in^2
Iyy		

rx = 1.34 in
ry =

Approximate Weight	
Plate	21.16
Web	3.31
Flange	2.64
W+FLG	5.95

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Side Transverses
L 8x4x7/16

Date:
Prepared by:

US L

Plate thickness	0.25	in
Plate width	32	in
Depth of Section	8	in
Web thickness	0.4375	in
Flange width	4	in
Flange thickness	0.4375	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	8.00	1.00	0.13	0.04
Web	4.03	3.31	13.34	54	15.77
Flange	8.03	1.75	14.05	113	0.03
Totals		13.06	28.39	167	15.84

Centroid	2.17 in
Ixx at centroid	121 in^4
SM pl	55.59 in^3
SM flg	19.89 in^3
Shear Area	3.61 in^2
Iyy	

rx = 3.04 in
ry =

Approximate Weight	
Plate	28.21
Web	11.67
Flange	6.17
W+FLG	17.84

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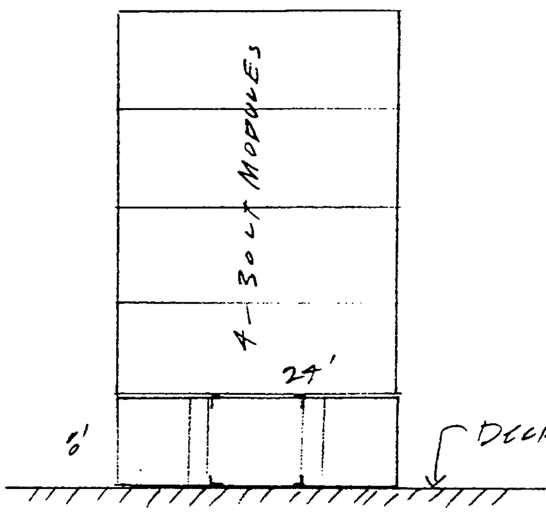
Calculation Sheet

Project No.:	969	Prepared By:	M. D	Date:	
Title:	ACB Lighter Development	Checked By:		Date:	
Subject:	Structure			Sheet	1 of 3

CHECK OF STOWAGE LOADS

Stowage Arrangement



Deck or tanktop of transport ship

Assumptions :

- Weight of stacked modules is carried at ISO corner fittings
- load at each fitting is carried by angle formed by transom and longitudinal bulkhead
- include transport ship dynamics.

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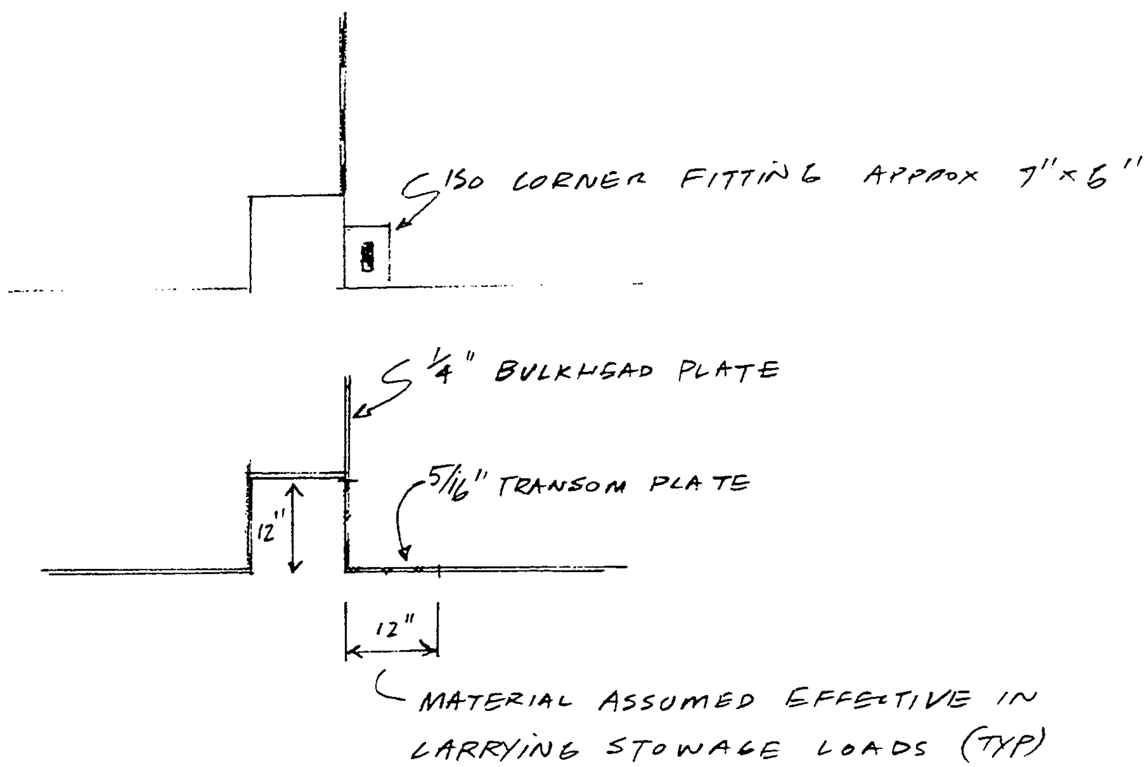
Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet 2 of 3

CORNER ARRANGEMENT



COMPRESSIVE STRESS

Load at each corner : $(4)(30)/4 = 30$ LT $= 67,200^k$

Dynamic [Ref 1] : 1.3

$\therefore$ Design Load $= (67.2)(1.3) = 87.36^k$

Area : $(12)(\frac{1}{4}) + (12)(\frac{5}{16}) = 6.75 \text{ in}^2$

$\therefore \sigma = 87.36/6.75 = \underline{\underline{12.94 \text{ ksi}}}$

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Calculation Sheet

Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject:

EFFECTIVENESS

Since there is no problem with instability (buckling) with this arrangement

allowable stress = (34)(0.67) = 22.78

∴ structure is sufficient

Reference :

1 "SEA-SHED, Removable 'Tween Deck Conversion System for Container Ships", US Dept of Transp. Volume 4 Stress Analysis, Synopsis provided by NFESC Dynamic Load Factor, PRESIDENT PIERCE.

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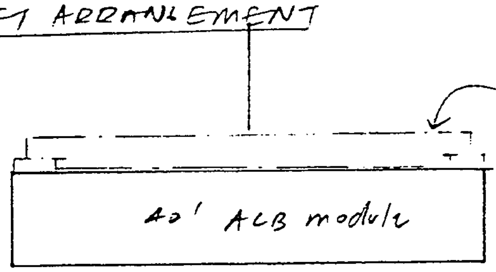
Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

CHECK OF LIFTING LOADS

LIFT ARRANGEMENT



LOAD

Assume maximum module wt 30 LT

Dynamics

Crane ship dynamic factor 1.3

Crane operational dynamics assume 2.0

Load per corner fitting

$$\frac{30 \times 2240 \times 1.3 \times 2.0}{(4)(1000)} = 43.7 \text{ k}$$

Tensile stress

Assume 12" x 12" corner section carries load

$$\sigma = \frac{43.7}{6.75} = 6.47 \text{ ksi} \qquad \text{ok}$$

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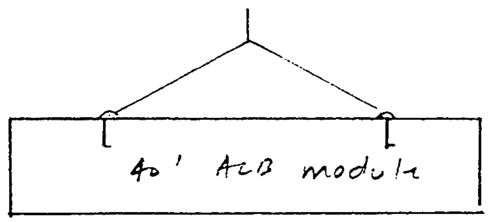
Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

LIFT ARRANGEMENT alternative



LOAD

Assume 30 LT

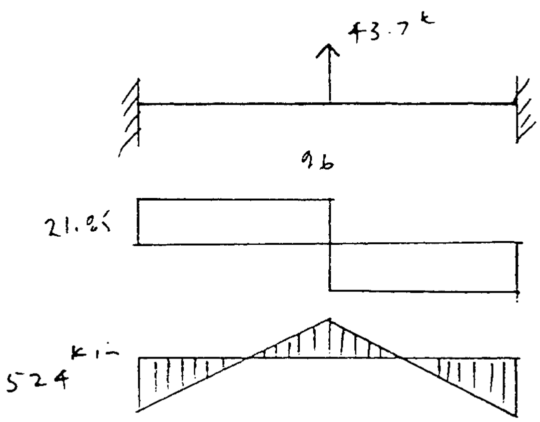
Dynamics

Crane ship 1.3
Crane 2.0

Load per lifting point

43.7 k

Support Arrangement



$SM_{req} = \frac{524}{34.17} = 15.33$

Provided FP 24 × 4 × 1/4

SM = 53.11 OK.

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Dynamic Load Factors Calculation

Reference: DOD Std 1399 Section 301A "Ship Motion and Attitude"

Vessel:	ACB Lighter 120 foot barge		
Length:	120 ft		
Beam:	24 ft		
Draft:	3.875 ft		
Displacement:	290 LT		
GM	ft		
LCG	60 ft		
VCG	9.9 ft		
TCG	0 ft		
gravity, g	32.15 ft/s^2		
Roll Constant, C			
Roll Period, Tp	5 sec		
Ptich Period, Tr	3.5 sec		Estimate from DOD Std
Roll Angle, PHI	6 deg		Estimate from DOD Std
Ptich Angle, THETA	2 deg		Estimate from DOD Std
Heave Acc., h	4 ft/s^2		Estimate from DOD Std
Surge Acc.,s	1.929 ft/s^2		Estimate from DOD Std
Height	8 ft	vert. lever z	-1.9
Offset	12 ft	horiz. level y	12

Load Factors (g)

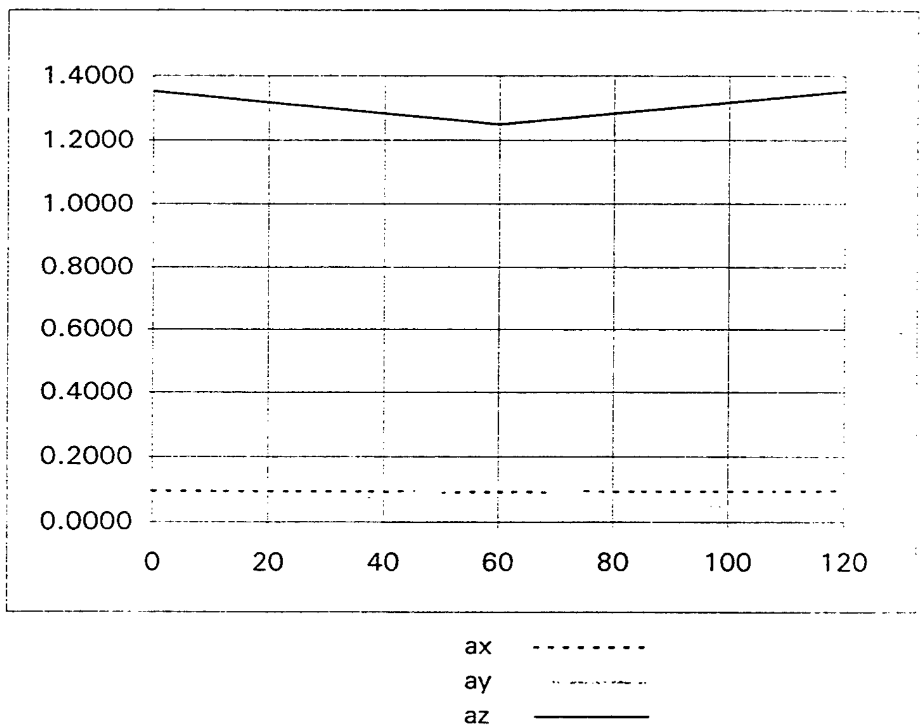
ax = {(g)(sin THETA) + s + (4PI^2/Tp^2)[(THETA)^2(x) + (THETA)(z)]}/g

ay = {(g)(sin PHI) + 1/2 - (4PI^2/Tp^2)(THETA)(x) + (4PI^2/Tr^2)[(THETA)^2 (y)+(THETA)(z)]}/g

az = {g + h + (4PI^2)[(THETA)(x)/Tp^2 + (PHI)(y)/Tr^2]}/g

position		x	ax	ay	az
0	0	60	0.0952	0.0105	1.3532
1	12	48	0.0945	0.0310	1.3326
2	24	36	0.0938	0.0516	1.3121
3	36	24	0.0931	0.0722	1.2915
4	48	12	0.0924	0.0927	1.2709
5	60	0	0.0916	0.1133	1.2504
6	72	12	0.0924	0.0927	1.2709
7	84	24	0.0931	0.0722	1.2915
8	96	36	0.0938	0.0516	1.3121
9	108	48	0.0945	0.0310	1.3326
10	120	60	0.0952	0.0105	1.3532

FIGURE 4.9
DYNAMIC LOAD FACTORS



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Calculation Sheet

Project No.: 969	Prepared By: M. D	Date:	
Title: Amphibious Cargo Beach	Checked By:	Date:	
Subject: Lighter — STRUCTURE		Sheet	of

LONGITUDINAL STRENGTH

Check scantlings for hull girder flexural response:

- check hull girder global section modulus against ABS Steel Barge Rules requirements
- calculate primary (hull girder bending) stresses to still water and wave bending moments under cargo loading
- check hydrodynamic bending moments reported in Connection system development report.

Hull Girder Section Modulus

The following page shows the calculated hull girder section modulus

The results are :

$$Z_{deck} = 819 \text{ in}^2 \text{ft}$$

$$Z_{keel} = 754 \text{ in}^2 \text{ft}$$

HULL GIRDER SECTION MODULUS CALCULATION

Amphibious Cargo Beaching Lighter

Midships

Hull girder maximum depth 8 ft Deck

Item	Scantlings	Area (in^2)	Height (ft)	Moment (in^2 ft)	2nd Moment (in^2 ft^2)	Local Inertia (in^2 ft ^2)
Bottom shell	144 x 1/4	36	0	0	0	
Bottom Longitudinals	5 @ L 5x3x5/16	12	0.333	4	1	
side shell	1/4 x 96	24	4	96	384	24
side longitudinals	3 @ L4x3x1/4	5.11	4	20	82	
longitudinal bulkheads	1/4 x 96	24	4	96	384	24
long bhd stiffeners	3@ L3x2x1/4	3.61	4	14	58	
deck plate	144 x 1/4	36	8	288	2304	
deck longitudinals	5 @ FP15x4x1/4	23.75	7	166	1164	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
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				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
Totals		164.47		685	4377	48

Height of neutral axis	na =	4.17	ft	
Half hull girder moment of inertia about baseline	1/2 I zz =	4425	in^2 ft^2	
Parallel axis term		2854	in^2 ft^2	
Half hull girder moment of inertia about neutral axis	1/2 I na =	1571	in^2 ft^2	
Full hull girder moment of inertia	I na =	3141	in^2 ft^2	
Full hull girder shear area	A =	329	in^2	0
Section Modulus to deck	Zd =	819	in^2 ft	
Section Modulus to keel	Zk =	754	In^2 ft	

ABS Rules for Steel Barges

Required Section Modulus is given by:

$$SM_R = k\,SM_b$$

$$k = 0.629\ M_s / (f_p\,SM_b) \quad \text{not less than } 1$$

assume $k = 1$

$$SM_b = C_1 C_2 L^2 B\,(C_b + 0.7)$$

$C_1 = 4.11$
$C_2 = 1.44 \times 10^{-4}$
$L = 120$ ft
$B = 24$ ft
$C_b \cong 0.98$

$$\therefore \quad SM_b = (4.11)(1.44\times10^{-4})(120)^2(24)\left[0.98 + 0.7\right]$$

$$= 344 \text{ in}^2\text{ ft}$$

$\therefore\ SM_R = 344 \text{ in}^2\text{ ft}$

Minimum section modulus provided =

$$Z_k = 754 \text{ in}^2\text{ ft} > 344$$

$\therefore$ Hull girder section is sufficient to ABS Rules

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Calculation Sheet

Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject: Sheet of

Primary Stress Levels

Loading Conditions

Check the following load conditions assumed to include worst case

- single M1A1 tank – still water condition
- 3-M1A1 tanks evenly loaded along barge – still water condition
- 3-M1A1 tanks closely spaced amidships – still water condition

Based on Results of these choose loading cases for calculating wave bending moments

Single M1A1 tank – still water

Maximum Shear = 28.8 LT
Maximum moment = 671 LT ft

3-M1A1 tanks evenly loaded – still water

Maximum shear = 32.4 LT
Maximum moment = 789 LT ft

3-M1A1 tanks closely spaced – still water

Maximum shear = 58 LT
Maximum moment = 1421 LT ft

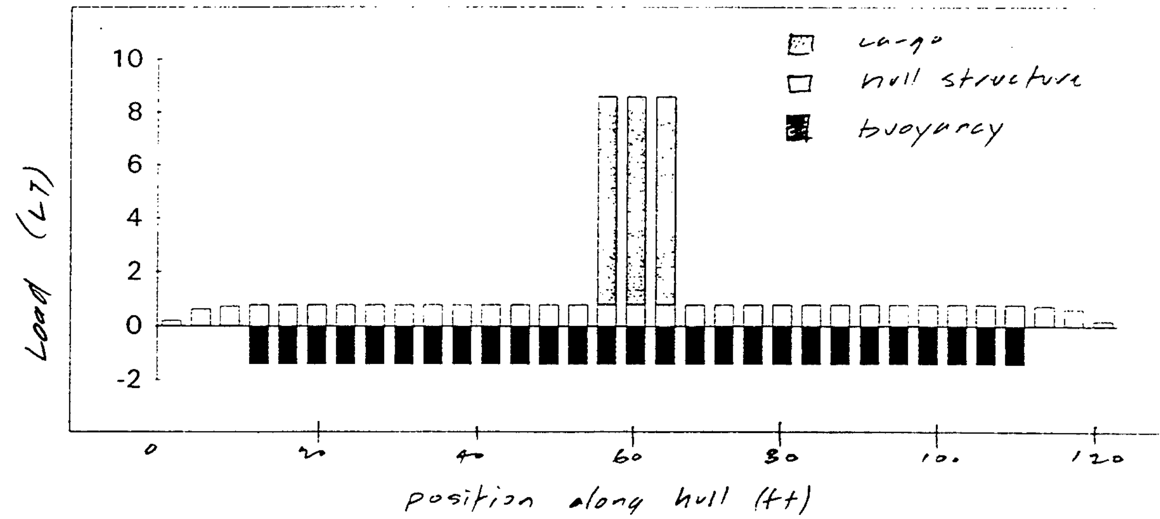
Bending Moment Calculation

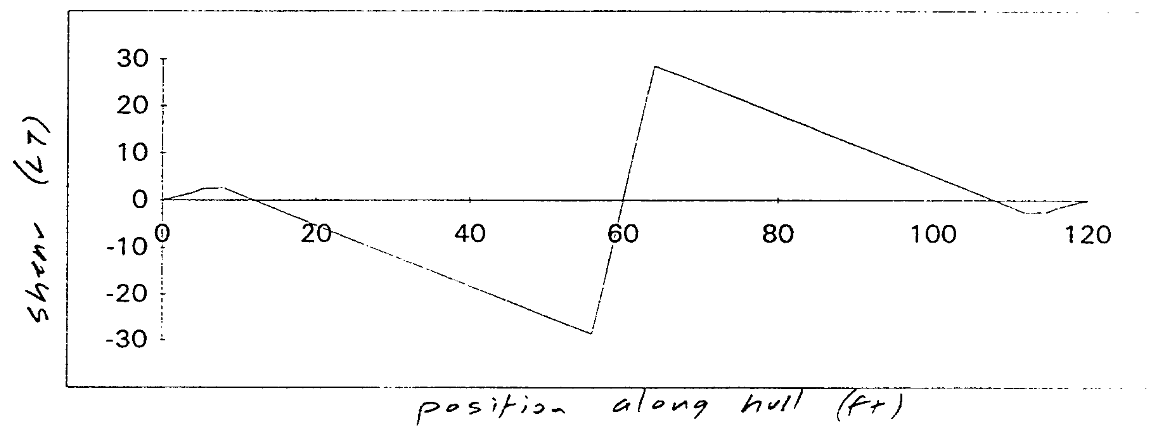
Amphibious Cargo Beaching Lighter

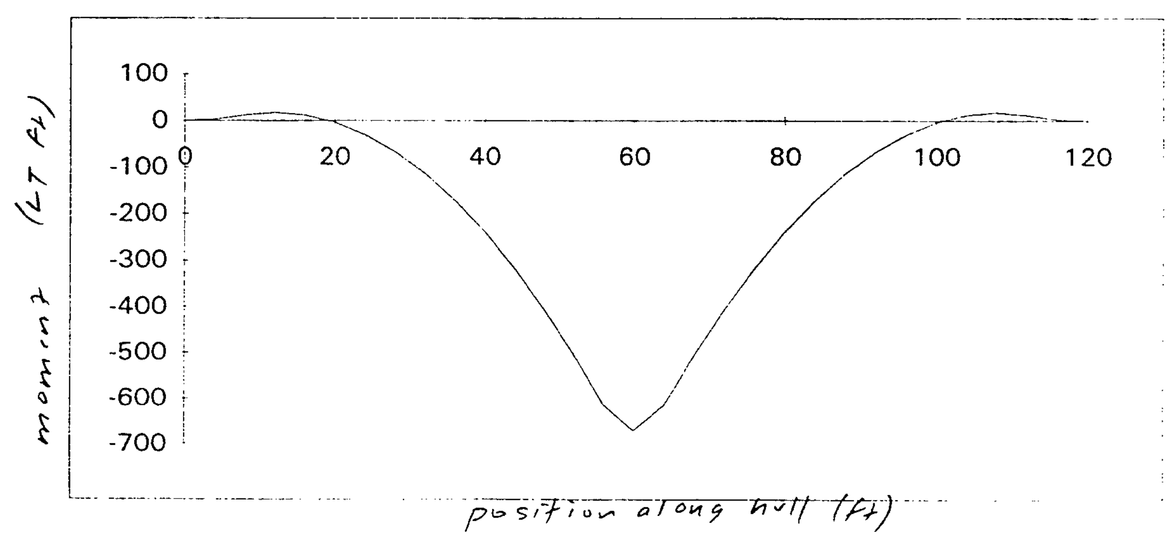
Load: 1 - M1A1 Tank
Total Displacement: 152.5 LT

Position	Buoyancy	Struture wt		Load	Net Load			Shear	Moment
					begin	end			
0	0	0.1964		0	0.1964	0.625	0	0	0
4	0	0.625		0	0.625	0.7394	1.6428	1.614239	3.228477
5.22	0	0.7394		0	0.7394	-0.6429	2.475084	2.437812	5.700228
8	-1.4286	0.7857		0	-0.6429	-0.6429	2.609219	2.552096	12.6362
12	-1.4286	0.7857		0	-0.6429	-0.6429	0.037619	-0.04806	17.64426
16	-1.4286	0.7857		0	-0.6429	-0.6429	-2.53398	-2.64823	12.25168
20	-1.4286	0.7857		0	-0.6429	-0.6429	-5.10558	-5.24839	-3.54154
24	-1.4286	0.7857		0	-0.6429	-0.6429	-7.67718	-7.84855	-29.7354
28	-1.4286	0.7857		0	-0.6429	-0.6429	-10.2488	-10.4487	-66.3299
32	-1.4286	0.7857		0	-0.6429	-0.6429	-12.8204	-13.0489	-113.325
36	-1.4286	0.7857		0	-0.6429	-0.6429	-15.392	-15.649	-170.721
40	-1.4286	0.7857		0	-0.6429	-0.6429	-17.9636	-18.2492	-238.517
44	-1.4286	0.7857		0	-0.6429	-0.6429	-20.5352	-20.8494	-316.714
48	-1.4286	0.7857		0	-0.6429	-0.6429	-23.1068	-23.4495	-405.312
52	-1.4286	0.7857		0	-0.6429	-0.6429	-25.6784	-26.0497	-504.311
56	-1.4286	0.7857	1	7.813	7.1696	7.1696	-28.25	-28.6498	-613.71
60	-1.4286	0.7857		7.813	7.1696	7.1696	0.428419	0	-671.009
64	-1.4286	0.7857	2	7.813	-0.6429	-0.6429	29.10682	28.64984	-613.71
68	-1.4286	0.7857		0	-0.6429	-0.6429	26.53522	26.04968	-504.311
72	-1.4286	0.7857		0	-0.6429	-0.6429	23.96362	23.44952	-405.312
76	-1.4286	0.7857		0	-0.6429	-0.6429	21.39202	20.84935	-316.714
80	-1.4286	0.7857		0	-0.6429	-0.6429	18.82042	18.24919	-238.517
84	-1.4286	0.7857		0	-0.6429	-0.6429	16.24882	15.64903	-170.721
88	-1.4286	0.7857		0	-0.6429	-0.6429	13.67722	13.04887	-113.325
92	-1.4286	0.7857		0	-0.6429	-0.6429	11.10562	10.44871	-66.3299
96	-1.4286	0.7857		0	-0.6429	-0.6429	8.534019	7.848549	-29.7354
100	-1.4286	0.7857		0	-0.6429	-0.6429	5.962419	5.248387	-3.54154
104	-1.4286	0.7857		0	-0.6429	-0.6429	3.390819	2.648226	12.25168
108	-1.4286	0.7857		0	-0.6429	-0.6429	0.819219	0.048065	17.64426
112	-1.4286	0.7857		0	-0.6429	0.7394	-1.75238	-2.5521	12.6362
114.78	0	0.7394		0	0.7394	0.625	-1.61825	-2.43781	5.700228
116	0	0.625		0	0.625	0.1964	-0.78596	-1.61424	3.228477
120	0	0.1964		0	0.1964	0	0.856838	1.55E-15	1.69E-14

Loading Shear and Moment Distributions







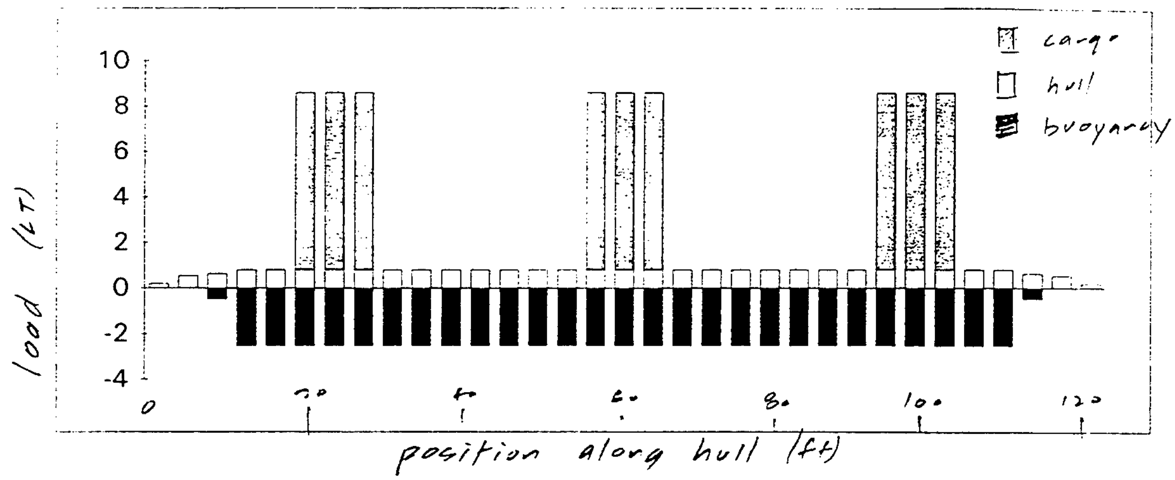
Bending Moment Calculation

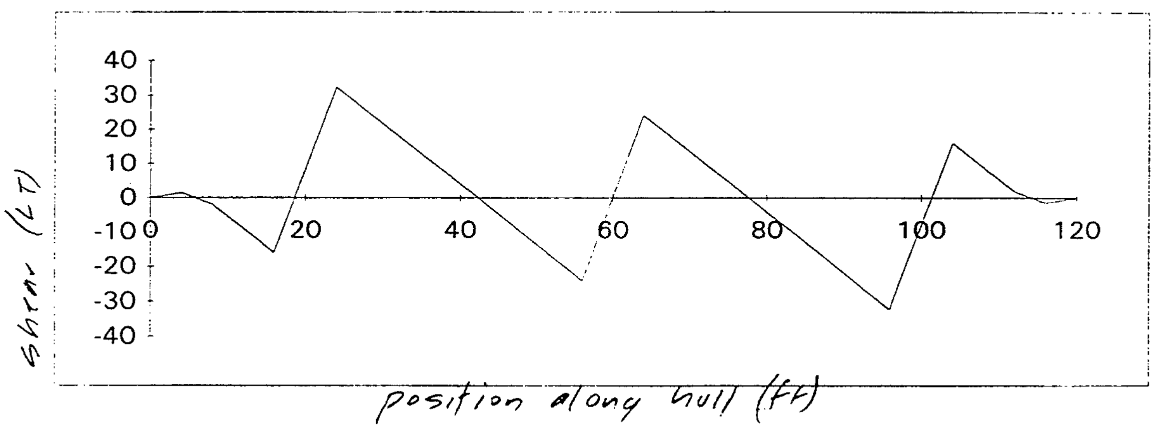
Amphibious Cargo Beaching Lighter

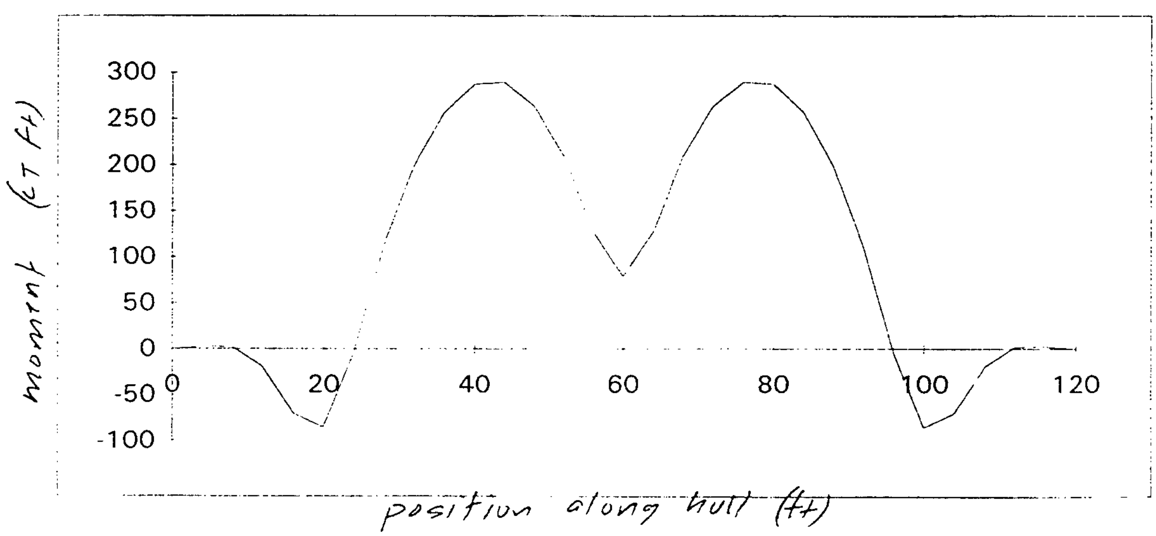
Load: 3 - M1A1 Tanks
Total Displacement: 277.5 LT

Position	Buoyancy	Struture wt		Load	Net Load			Shear	Moment
					begin	end			
0	0	0.1964		0	0.1964	0.5359	0	0	0
3.05	0	0.5359		0	0.5359	0.1344	1.116758	1.101002	1.679028
4	-0.4906	0.625		0	0.1344	-1.762	1.43515	1.414487	2.873885
8	-2.5477	0.7857		0	-1.762	-1.762	-1.82005	-1.86138	1.980105
12	-2.5477	0.7857		0	-1.762	-1.762	-8.86805	-8.93004	-19.6027
16	-2.5477	0.7857	1	7.813	6.051	6.051	-15.9161	-15.9987	-69.4602
20	-2.5477	0.7857		7.813	6.051	6.051	8.28795	8.184633	-85.0884
24	-2.5477	0.7857	2	7.813	-1.762	-1.762	32.49195	32.36797	-3.98315
28	-2.5477	0.7857		0	-1.762	-1.762	25.44395	25.29931	111.3514
32	-2.5477	0.7857		0	-1.762	-1.762	18.39595	18.23064	198.4113
36	-2.5477	0.7857		0	-1.762	-1.762	11.34795	11.16198	257.1966
40	-2.5477	0.7857		0	-1.762	-1.762	4.29995	4.093317	287.7071
44	-2.5477	0.7857		0	-1.762	-1.762	-2.74805	-2.97535	289.9431
48	-2.5477	0.7857		0	-1.762	-1.762	-9.79605	-10.044	263.9044
52	-2.5477	0.7857		0	-1.762	-1.762	-16.8441	-17.1127	209.591
56	-2.5477	0.7857	1	7.813	6.0505	6.0505	-23.8921	-24.1813	127.003
60	-2.5477	0.7857		7.813	6.0505	6.0505	0.30995	0	78.64031
64	-2.5477	0.7857	2	7.813	-1.762	-1.762	24.51195	24.18134	127.003
68	-2.5477	0.7857		0	-1.762	-1.762	17.46395	17.11267	209.591
72	-2.5477	0.7857		0	-1.762	-1.762	10.41595	10.04401	263.9044
76	-2.5477	0.7857		0	-1.762	-1.762	3.36795	2.975347	289.9431
80	-2.5477	0.7857		0	-1.762	-1.762	-3.68005	-4.09332	287.7071
84	-2.5477	0.7857		0	-1.762	-1.762	-10.7281	-11.162	257.1966
88	-2.5477	0.7857		0	-1.762	-1.762	-17.7761	-18.2306	198.4113
92	-2.5477	0.7857		0	-1.762	-1.762	-24.8241	-25.2993	111.3514
96	-2.5477	0.7857	1	7.813	6.051	6.051	-31.8721	-32.368	-3.98315
100	-2.5477	0.7857		7.813	6.051	6.051	-7.66805	-8.18463	-85.0884
104	-2.5477	0.7857	2	7.813	-1.762	-1.762	16.53595	15.9987	-69.4602
108	-2.5477	0.7857		0	-1.762	-1.762	9.48795	8.93004	-19.6027
112	-2.5477	0.7857		0	-1.762	0.1344	2.43995	1.861377	1.980105
116	-0.4906	0.625		0	0.1344	0.5359	-0.81525	-1.41449	2.873885
116.95	0	0.5359		0	0.5359	0.1964	-0.49686	-1.101	1.679028
120	0	0.1964		0	0.1964	0	0.6199	-1.6E-15	-2.2E-15

Loading Shear and Moment Distributions







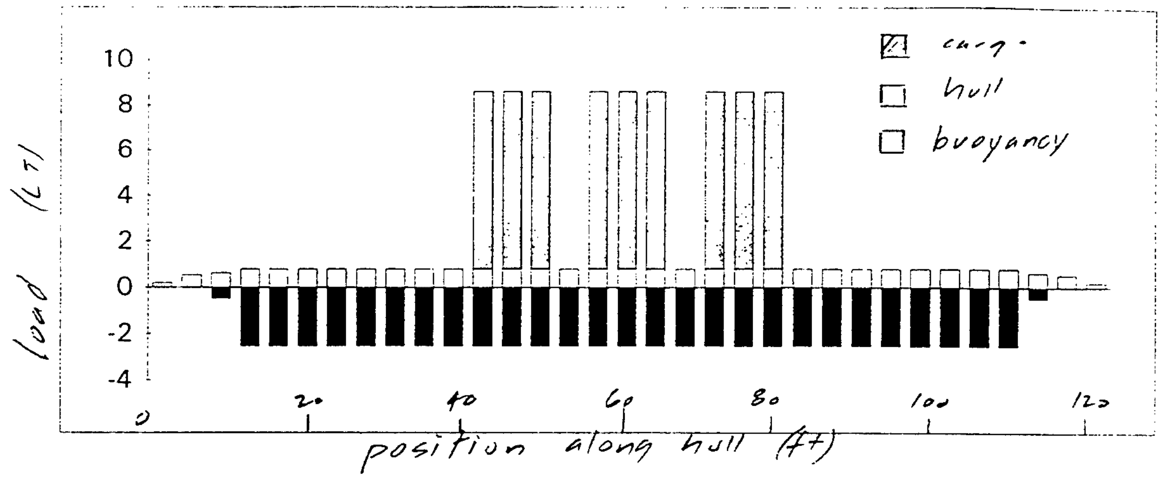
Bending Moment Calculation

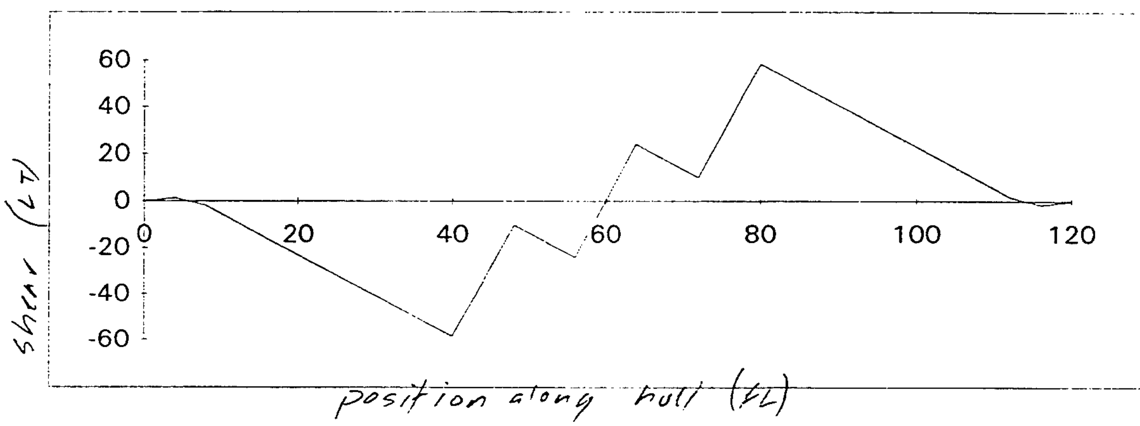
Amphibious Cargo Beaching Lighter

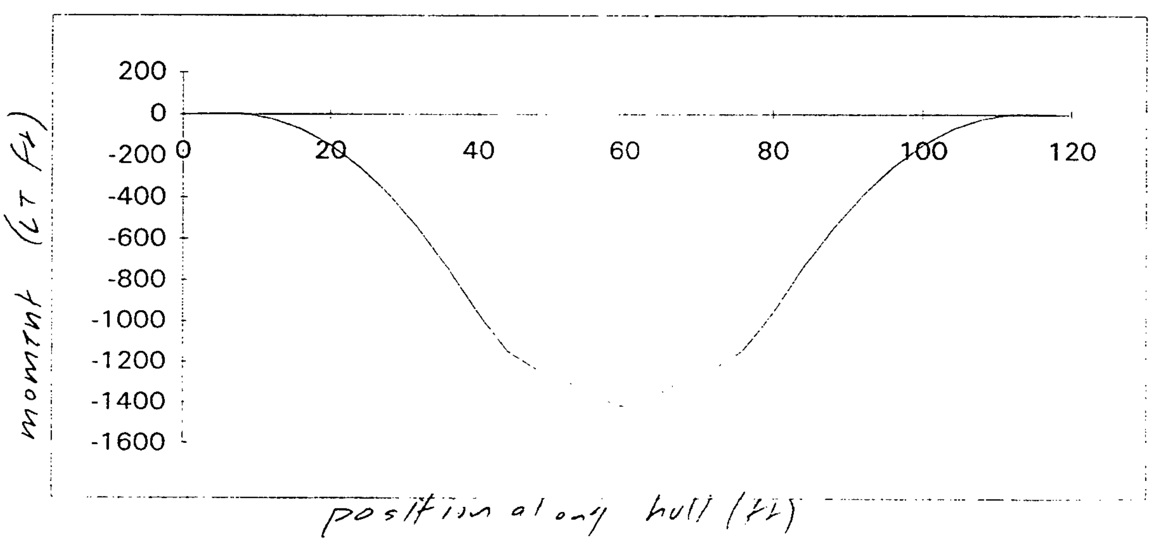
Load: 3 - M1A1 Tanks Closely Spaced
Total Displacement: 277.5 LT

Position	Buoyancy	Struture wt		Load	Net Load			Shear	Moment
					begin	end			
0	0	0.1964		0	0.1964	0.5359	0	0	0
3.05	0	0.5359		0	0.5359	0.1344	1.116758	1.101205	1.679338
4	-0.4906	0.625		0	0.1344	-1.762	1.43515	1.414753	2.874418
8	-2.5477	0.7857		0	-1.762	-1.762	-1.82005	-1.86084	1.982238
12	-2.5477	0.7857		0	-1.762	-1.762	-8.86805	-8.92924	-19.5979
16	-2.5477	0.7857		0	-1.762	-1.762	-15.9161	-15.9976	-69.4517
20	-2.5477	0.7857		0	-1.762	-1.762	-22.9641	-23.066	-147.579
24	-2.5477	0.7857		0	-1.762	-1.762	-30.0121	-30.1344	-253.98
28	-2.5477	0.7857		0	-1.762	-1.762	-37.0601	-37.2028	-388.654
32	-2.5477	0.7857		0	-1.762	-1.762	-44.1081	-44.2712	-551.603
36	-2.5477	0.7857		0	-1.762	-1.762	-51.1561	-51.3396	-742.824
40	-2.5477	0.7857	1	7.813	6.0505	6.0505	-58.2041	-58.408	-962.32
44	-2.5477	0.7857		7.813	6.0505	6.0505	-34.0021	-34.2264	-1147.59
48	-2.5477	0.7857	2	7.813	-1.762	-1.762	-9.80005	-10.0448	-1236.13
52	-2.5477	0.7857		0	-1.762	-1.762	-16.8481	-17.1132	-1290.45
56	-2.5477	0.7857	1	7.813	6.0505	6.0505	-23.8961	-24.1816	-1373.04
60	-2.5477	0.7857		7.813	6.0505	6.0505	0.30595	0	-1421.4
64	-2.5477	0.7857	2	7.813	-1.762	-1.762	24.50795	24.1816	-1373.04
68	-2.5477	0.7857		0	-1.762	-1.762	17.45995	17.11321	-1290.45
72	-2.5477	0.7857	1	7.813	6.0505	6.0505	10.41195	10.04481	-1236.13
76	-2.5477	0.7857		7.813	6.0505	6.0505	34.61395	34.22641	-1147.59
80	-2.5477	0.7857	2	7.813	-1.762	-1.762	58.81595	58.40802	-962.32
84	-2.5477	0.7857		0	-1.762	-1.762	51.76795	51.33962	-742.824
88	-2.5477	0.7857		0	-1.762	-1.762	44.71995	44.27122	-551.603
92	-2.5477	0.7857		0	-1.762	-1.762	37.67195	37.20283	-388.654
96	-2.5477	0.7857		0	-1.762	-1.762	30.62395	30.13443	-253.98
100	-2.5477	0.7857		0	-1.762	-1.762	23.57595	23.06603	-147.579
104	-2.5477	0.7857		0	-1.762	-1.762	16.52795	15.99764	-69.4517
108	-2.5477	0.7857		0	-1.762	-1.762	9.47995	8.92924	-19.5979
112	-2.5477	0.7857		0	-1.762	0.1344	2.43195	1.860843	1.982238
116	-0.4906	0.625		0	0.1344	0.5359	-0.82325	-1.41475	2.874418
116.95	0	0.5359		0	0.5359	0.1964	-0.50486	-1.10121	1.679338
120	0	0.1964		0	0.1964	0	0.6119	-1.6E-15	1.01E-13

Loading Shear and Moment Distributions







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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Wave Bending Load Conditions

Based on still water cases, 3-M1A1 tanks closely spaced results in largest moment (as expected). Place this load on sagging (trough amidships) wave. In addition review a hogging condition with 2-M1A1 tanks at ends

Balance the barge form on a L/20 trochoidal wave (classical naval architectural approach)

L/20 wave:

wavelength 120 ft
crest-trough height 6 ft

3-M1A1 tanks closely spaced on a sagging wave

Maximum Shear = 90 LT
Maximum Moment = 2830 LT ft

2-M1A1 tanks at ends on a hogging wave

Maximum shear = 73 LT
Maximum moment = 2030 LT ft

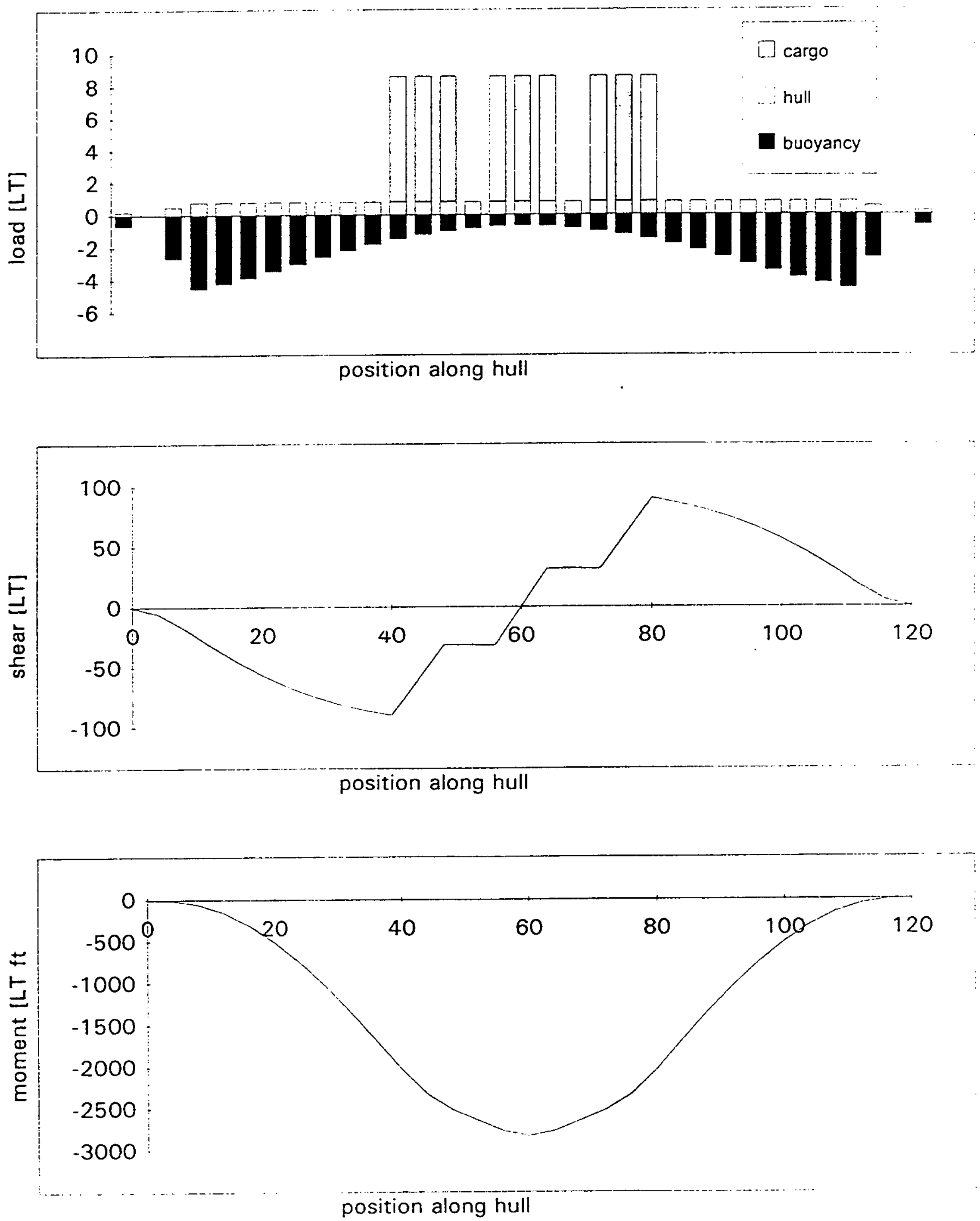
Bending Moment Calculation

Amphibious Cargo Beaching Lighter

Load: 3 - M1A1 Tanks Closely Spaced
Total Displacement: 277.5 LT

Position	Buoyancy	Struture wt		Load	Net Load			Shear	Moment
					begin	end			
0	-0.69	0.1964		0	-0.4936	-2.1929	0	0	0
0	0	0		0	0	0	0	0	0
4	-2.684	0.4911		0	-2.1929	-3.7743	-5.373	-5.2796	-10.5592
8	-4.56	0.7857		0	-3.7743	-3.4813	-17.3074	-17.1206	-55.3596
12	-4.267	0.7857		0	-3.4813	-3.1303	-31.8186	-31.5384	-152.678
16	-3.916	0.7857		0	-3.1303	-2.7203	-45.0418	-44.6682	-305.091
20	-3.506	0.7857		0	-2.7203	-2.2873	-56.743	-56.276	-506.979
24	-3.073	0.7857		0	-2.2873	-1.8543	-66.7582	-66.1978	-751.927
28	-2.64	0.7857		0	-1.8543	-1.4393	-75.0414	-74.3876	-1033.1
32	-2.225	0.7857		0	-1.4393	-1.0573	-81.6286	-80.8814	-1343.64
36	-1.843	0.7857		0	-1.0573	-1.0573	-86.6218	-85.7812	-1676.96
40	-1.505	0.7857	1	7.813	7.0932	7.3722	-90.851	-89.917	-2028.36
44	-1.226	0.7857		7.813	7.3722	7.3722	-61.9202	-60.8928	-2329.98
48	-1.021	0.7857	2	7.813	-0.0703	-0.0703	-32.4314	-31.3106	-2514.38
52	-0.856	0.7857		0	-0.0703	-0.0703	-32.7126	-31.4984	-2640
56	-0.73	0.7857	1	7.813	7.8682	7.9082	-32.9938	-31.6862	-2766.37
60	-0.69	0.7857		7.813	7.9082	7.9082	-1.441	-0.04	-2829.82
64	-0.73	0.7857	2	7.813	-0.0703	-0.0703	30.1918	31.6862	-2766.53
68	-0.856	0.7857		0	-0.0703	-0.0703	29.9106	31.4984	-2640.16
72	-1.021	0.7857	1	7.813	7.3722	7.3722	29.6294	31.3106	-2514.54
76	-1.226	0.7857		7.813	7.3722	7.0932	59.1182	60.8928	-2330.14
80	-1.505	0.7857	2	7.813	-1.0573	-1.0573	88.049	89.917	-2028.52
84	-1.843	0.7857		0	-1.0573	-1.4393	83.8198	85.7812	-1677.12
88	-2.225	0.7857		0	-1.4393	-1.8543	78.8266	80.8814	-1343.8
92	-2.64	0.7857		0	-1.8543	-2.2873	72.2394	74.3876	-1033.26
96	-3.073	0.7857		0	-2.2873	-2.7203	63.9562	66.1978	-752.087
100	-3.506	0.7857		0	-2.7203	-3.1303	53.941	56.276	-507.139
104	-3.916	0.7857		0	-3.1303	-3.4813	42.2398	44.6682	-305.251
108	-4.267	0.7857		0	-3.4813	-3.7743	29.0166	31.5384	-152.838
112	-4.56	0.7857		0	-3.7743	-2.1929	14.5054	17.1206	-55.5196
116	-2.684	0.4911		0	-2.1929	-0.4936	2.571	5.2796	-10.7192
120	0	0		0	0	0		0	
120	-0.69	0.1964		0	-0.4936	0	-2.802	0	0

Loading Shear and Moment Distributions



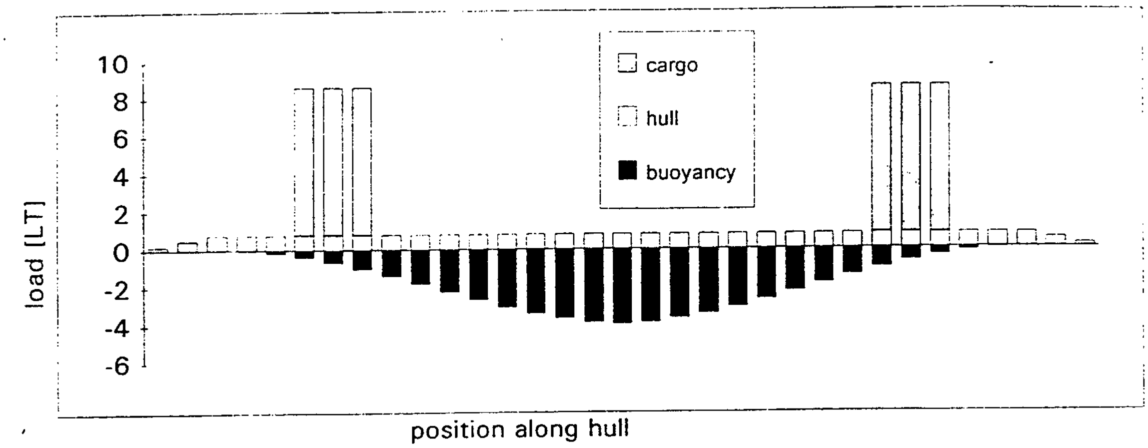
Bending Moment Calculation

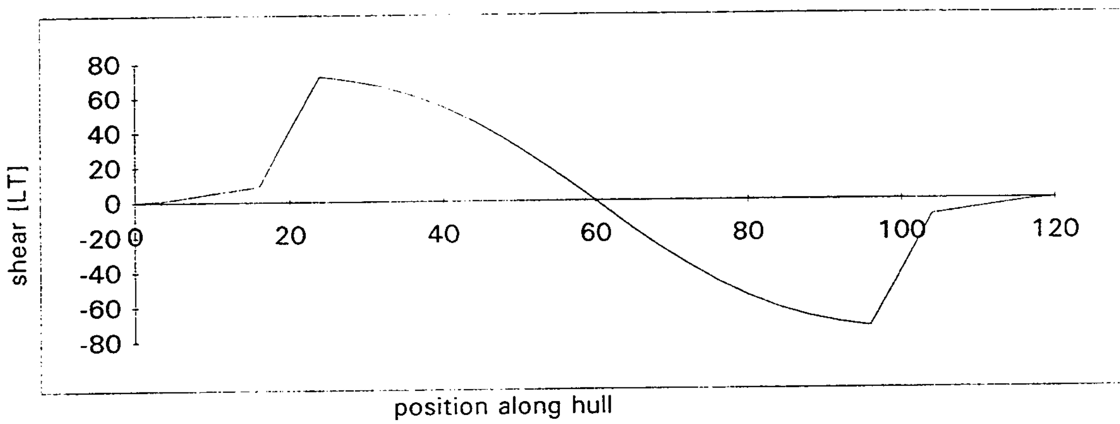
Amphibious Cargo Beaching Lighter

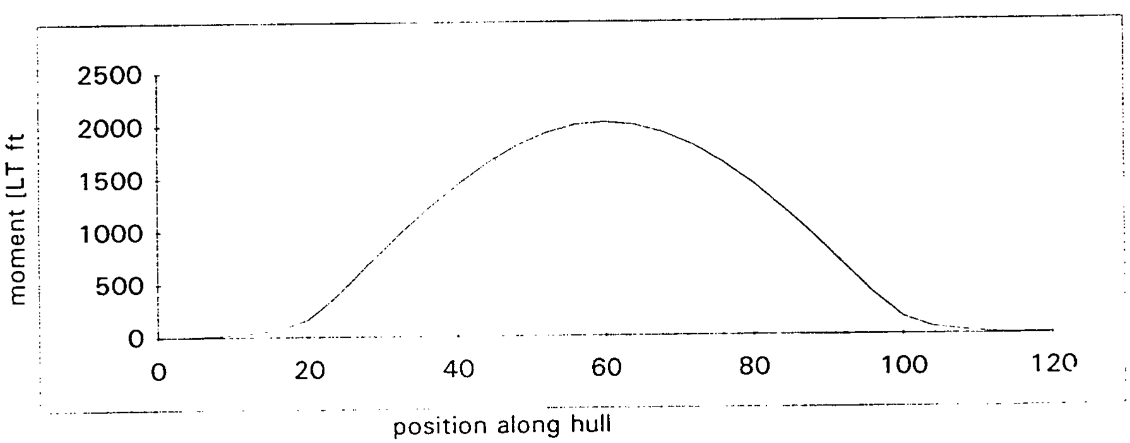
Load: 2 - M1A1 Tanks At Ends Hogging Wave
Total Displacement: 215 LT

Position	Buoyancy	Struture wt		Load	Net Load begin	end		Shear	Moment
0	0	0.1964		0	0.1964	0.4911	0	0	0
4	0	0.4911		0	0.4911	0.7828	1.375	1.342425	2.684851
7.96	0	0.7828		0	0.7828	0.762	3.897322	3.832499	15.25334
8	-0.0237	0.7857		0	0.762	0.596	3.928218	3.863069	15.40726
12	-0.1897	0.7857		0	0.596	0.596	6.644218	6.546494	36.22638
16	-0.418	0.7857	1	7.813	8.1802	7.8939	9.028218	8.89792	67.11521
20	-0.7043	0.7857		7.813	7.8939	7.8939	41.17642	41.01355	166.9381
24	-1.0426	0.7857	2	7.813	-0.6386	-0.6386	72.75202	72.55657	394.0784
28	-1.4243	0.7857		0	-0.6386	-1.0534	70.19762	69.9696	679.1307
32	-1.8391	0.7857		0	-1.0534	-1.4865	66.81362	66.55302	952.1759
36	-2.2722	0.7857		0	-1.4865	-1.9194	61.73382	61.44065	1208.163
40	-2.7051	0.7857		0	-1.9194	-2.324	54.92202	54.59627	1440.237
44	-3.1097	0.7857		0	-2.324	-2.6582	46.43522	46.0769	1641.583
48	-3.4439	0.7857		0	-2.6582	-2.9178	36.47082	36.07992	1805.897
52	-3.7035	0.7857		0	-2.9178	-3.1398	25.31882	24.89535	1927.848
56	-3.9255	0.7857		0	-3.1398	-3.2177	13.20362	12.74757	2003.133
60	-4.0034	0.7857		0	-3.2177	-3.1398	0.488618	0	2028.629
64	-3.9255	0.7857		0	-3.1398	-2.9178	-12.2264	-12.7476	2003.133
68	-3.7035	0.7857		0	-2.9178	-2.6582	-24.3416	-24.8953	1927.848
72	-3.4439	0.7857		0	-2.6582	-2.324	-35.4936	-36.0799	1805.897
76	-3.1097	0.7857		0	-2.324	-1.9194	-45.458	-46.0769	1641.583
80	-2.7051	0.7857		0	-1.9194	-1.4865	-53.9448	-54.5963	1440.237
84	-2.2722	0.7857		0	-1.4865	-1.0534	-60.7566	-61.4406	1208.163
88	-1.8391	0.7857		0	-1.0534	-0.6386	-65.8364	-66.553	952.1759
92	-1.4243	0.7857		0	-0.6386	-0.6386	-69.2204	-69.9696	679.1307
96	-1.0426	0.7857	1	7.813	7.8939	7.8939	-71.7748	-72.5566	394.0784
100	-0.7043	0.7857		7.813	7.8939	8.1802	-40.1992	-41.0135	166.9381
104	-0.418	0.7857	2	7.813	0.596	0.596	-8.05098	-8.89792	67.11521
108	-0.1897	0.7857		0	0.596	0.762	-5.66698	-6.54649	36.22638
112	-0.0237	0.7857		0	0.762	0.7828	-2.95098	-3.86307	15.40726
112.04	0	0.7828		0	0.7828	0.4911	-2.92009	-3.8325	15.25334
116	0	0.4911		0	0.4911	0.1964	-0.39776	-1.34243	5.006995
120	0	0.1964		0	0.1964	0	0.977236	-8.4E-15	2.322144

Loading Shear and Moment Distributions







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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Primary Stress Levels

Allowable primary stress levels are general derived based on a stress budgeting approach

ABS steel barge rules use an allowable primary stress of 11.33 LT/in² (25.38 ksi)

Other references use 10 LT/in² (22.4 ksi)

For higher strength steels higher allowable stresses can be used

Sagging Condition (wave trough amidships)

The sagging condition puts the deck in compression and the bottom shell in tension

Worst case

$$\sigma_{deck} = 2830/819 = 3.46\ LT/in^2 \text{ (compression)}$$
$$= \underline{7.74}\ ksi$$

$$\sigma_{\text{bottom shell}} = 2830/754 = 3.75\ LT/in^2 \text{ (tension)}$$
$$= \underline{8.41}\ ksi$$

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Calculation Sheet

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Hogging Condition (wave crest amidships)

The hogging condition puts the deck in tension and the bottom shell in compression

Worst case:

$$\sigma_{deck} = 2030/819 = 2.48\ LT/in^2\ (tension) = \underline{5.5\ ksi}$$

$$\sigma_{bottom\ shell} = 2030/754 = 2.69\ LT/in^2\ (compression) = \underline{6.03\ ksi}$$

Subject to a review of global buckling, these stress are well with the allowable limits.

Shear Stresses

Allowable shear stress levels from ABS, 7.12 LT/in² (15.95 ksi)

Without a proper shear flow analysis of the hull girder, assume all shear is carried by side shell and two longitudinal bulkheads

$$\text{Shear area} = (4)(0.25)(8)(12) = 96\ in^2$$

$$\tau_{max} = 90/96 = 0.9375\ LT/in^2 = \underline{2.1\ ksi}$$

Well within allowable limits

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Project No.:	Prepared By:	Date:
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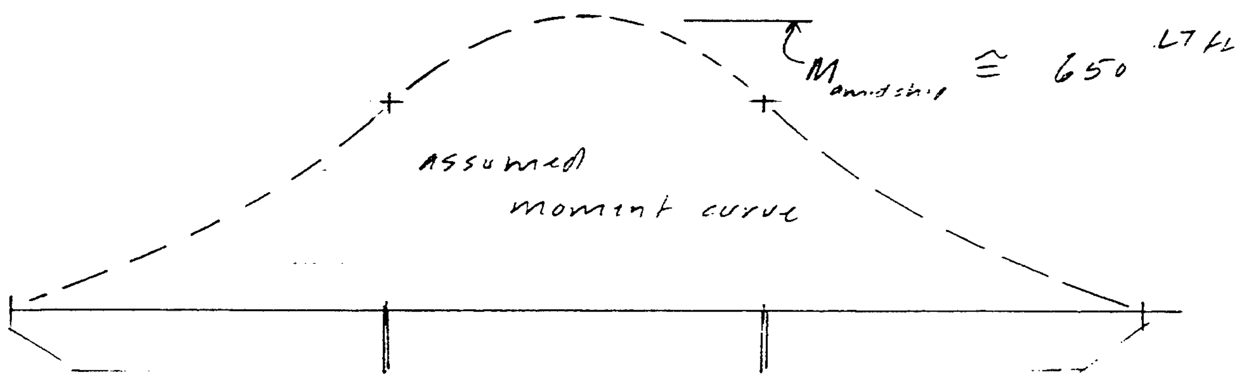
Check Hydrodynamic Bending Moment

Ref: Huang, E. T., "Conceptual Development of Open Sea Module Connection Techniques", NFESC, TM-2061-AMP, 1995

Table 5.2 from this reference gives a maximum hydrodynamic bending moment of

10.16×10^2 k ft = 454 LT ft

at module - module interface in S.S. 2.5



Assuming a 50% increase in moment for S.S. 3

$M_{max} \Rightarrow (650)(1.5) = 975$ LT ft

This is less than maximum "static" bending moment already checked

∴ does not govern

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Check Global Load Buckling

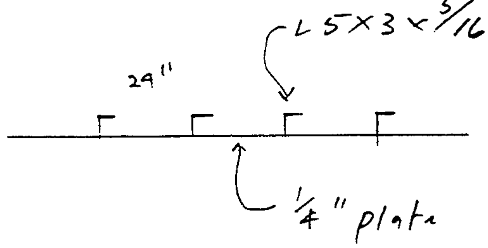
Maximum Primary compressive stresses

σ_{deck} = 7.74 ksi from sagging condition

$\sigma_{bottom\ shell}$ = 6.03 ksi from hogging condition

Bottom Shell

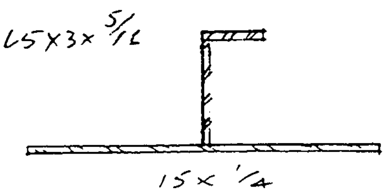
Check plate/stiffener "column" strength



ordinary strength steel

Effective breadth of attached plate

$$\min\{60t, L_n/3\} = \min\{(60)(0.25), 96/3\} = 15 \text{ in}$$



A = 6.15

Z_{fl} = 6.26

Z_{pl} = 16.09

r = 1.96

Critical Buckling Stress

$$\sigma_{cr} = \left(\frac{F_c}{F_y}\right) F_y$$

F_c/F_y from Fig 1 DDS 100-4

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Bottom Longitudinals
L 5x3x5/16

Date:
Prepared by:

US L

Plate thickness	0.25	in
Plate width	15	in
Depth of Section	5	in
Web thickness	0.3125	in
Flange width	3	in
Flange thickness	0.3125	in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	3.75	0.47	0.06	0.02
Web	2.59	1.46	3.80	10	2.68
Flange	5.09	0.94	4.78	24	0.01
Totals		6.15	9.04	34	2.71

		Centroid	1.47 in
		Ixx at centroid	24 in^4
		SM pl	16.09 in^3
rx =	1.96 in	SM flg	6.26 in^3
ry =		Shear Area	1.64 in^2
		Iyy	

Approximate Weight	
Plate	13.22
Web	5.17
Flange	3.31
W+FLG	8.47

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
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Buckling factor $c = k \frac{L_u}{r}\sqrt{\frac{F_y}{E}}$

$= (1)\frac{96}{1.96}\sqrt{\frac{34}{30\times10^3}} = 1.65$

$\therefore F_c/F_y = 0.96$

$\therefore \sigma_c = F_c = (0.96)(34) = 32.6$ ksi

$\sigma = 6.03 < \sigma_{cr} = 32.6 \therefore$ plate/stiff. is stable

Check Plate panel

Plate Buckling Factor; $\beta = \frac{b}{t}\sqrt{\frac{F_y}{E}} = \frac{24}{0.25}\sqrt{\frac{34}{30\times10^3}} = 3.23$

F_u/F_y from Fig 4 DDS 100-4

$F_u/F_y \Big|_{\beta=3.23} = 0.58$

$\therefore F_u = (0.58)(34) = 19.72$ ksi

$\sigma < F_u \therefore$ plate is stable

KVÆRNER

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Calculation Sheet

Project No.:	Prepared By:	Date:
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Check combined primary and secondary stress

Secondary stress (stress to local flexural response) from hydrostatic loading

Moment = 65.3 k in

SM_{pl} = 24.01 in^3

$\therefore \quad \sigma = \frac{65.3}{24.01} = 2.72$ ksi

For combined stress use interaction formula

$$\frac{\sigma_{primary}}{\sigma_{cr}} + \frac{\sigma_{secondary}}{\sigma_{all}} \leq 1$$

$$\frac{6.07}{32.6} + \frac{2.72}{22.8} = 0.3 \ll 1$$

$\therefore$ Bottom shell ok

$\therefore$ Bottom structure will not buckle

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Calculation Sheet

Project No.:	Prepared By:	Date:
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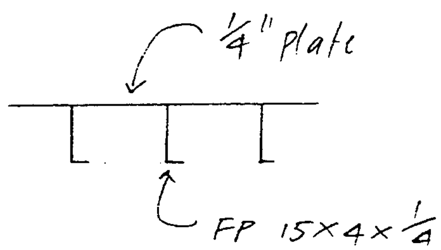
Subject:		Sheet of

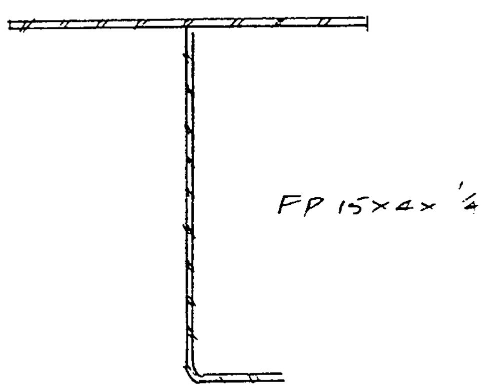
Deck Structure

Check plate/beam "column" strength



high strength steel

Effective Breadth of Plating 15 in



$A = 8.25$

$Z_{pl} = 25.74$

$Z_{st} = 53.47$

$r = 5.67$

Critical buckling stress

Buckling factor $C = k\frac{l_u}{r}\sqrt{\frac{F_y}{E}} = (1)\frac{96}{5.67}\sqrt{\frac{51}{30\times10^3}} = 0.698$

$F_c/F_y = 1 \quad \therefore \; F_c = F_y = 51$ ksi

$\sigma = 7.14 < F_c \quad \therefore$ plate/beam does not buckle

KVÆRNER

CALCULATION OF SECTION PROPERTIES

ACB Lighter
Project No. 969

Deck Beams
FP 15x4x1/4

Date:
Prepared by:

US FP

Plate thickness	0.25 in
Plate width	15 in
Depth of Section	15 in
Web thickness	0.25 in
Flange width	4 in
Flange thickness	0.25 in

Section Piece	y (in)	Area (in^2)	Area*y (in^3)	Area*y^2 (in^4)	Io (in^4)
Plate	0.13	3.75	0.47	0.06	0.02
Web	7.50	3.63	27.19	204	63.51
Flange	15.13	0.88	13.23	200	0.01
Totals		8.25	40.89	404	63.54

		Centroid	4.96 in
		Ixx at centroid	265 in^4
		SM pl	53.47 in^3
rx =	5.67 in	SM flg	25.74 in^3
ry =		Shear Area	3.81 in^2
		Iyy	

Approximate Weight	
Plate	13.22
Web	12.78
Flange	3.09
W+FLG	15.87

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Check proportion for tripping of Flanges

Flange-to-depth ratio $b_f/d = 4/15 = 0.27$

L_u/b_f maximum from Fig 8H DDS 100-4

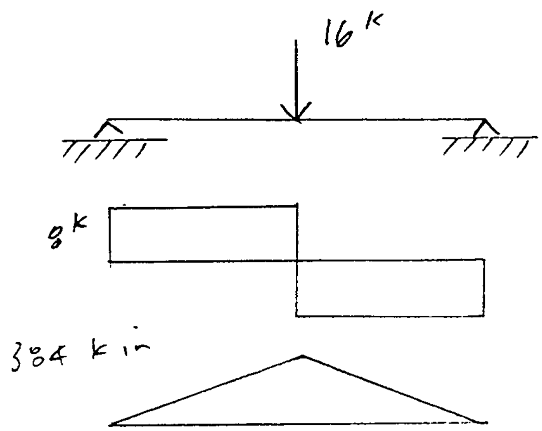
$L_u/b_f = 23$

$\therefore L_{u\,max} = (23)(4) = 92$ in

since stress levels are so low this should be ok

Check combined Primary and secondary stress

secondary stress from heavy cargo truck wheel load



$\sigma = \frac{384}{78} = 4.92$ ksi

$\frac{\sigma_{primary}}{\sigma_{cr}} + \frac{\sigma_{second}}{\sigma_{all}} = \frac{7.74}{51} + \frac{4.92}{34.17} = 0.3 < 1$ ok

KVÆRNER

Kaerner Masa Marine Inc.

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Check Plate Panel

Plate Buckling Factor ; $\beta = \frac{b}{t}\sqrt{\frac{F_y}{E}} = \frac{24}{0.25}\sqrt{\frac{51}{30\times10^3}} = 3.95$

$F_u/F_y \Big|_{\beta=3.95} = 0.48$

$\therefore F_u = (0.48)(51) = 24.48$

$\therefore \sigma = 7.74 < F_u = 24.48 \therefore$ plate will not buckle

Sectional Areas at Various Loading Cases

1 M1A1 Tank Still Water

Part: HULL Component: HULL.C Side: CL Effectiveness: 1.000

Origin Depth: 2.083 Trim: zero Heel: zero

HULL.C COMPONENT SECTIONS

Section Location	Baseline Depth	Section Area	TCtr	VCtr	Waterline Width	Ctr
60.00f	2.08					
...						
54.78f	2.08	0.00	0.00	2.08	24.00	0.00
52.00f	2.08	50.00	0.00	1.04	24.00	0.00
48.00f	2.08	50.00	0.00	1.04	24.00	0.00
44.00f	2.08	50.00	0.00	1.04	24.00	0.00
40.00f	2.08	50.00	0.00	1.04	24.00	0.00
36.00f	2.08	50.00	0.00	1.04	24.00	0.00
32.00f	2.08	50.00	0.00	1.04	24.00	0.00
28.00f	2.08	50.00	0.00	1.04	24.00	0.00
24.00f	2.08	50.00	0.00	1.04	24.00	0.00
20.00f	2.08	50.00	0.00	1.04	24.00	0.00
15.00f	2.08	50.00	0.00	1.04	24.00	0.00
10.00f	2.08	50.00	0.00	1.04	24.00	0.00
5.00f	2.08	50.00	0.00	1.04	24.00	0.00
0.00	2.08	50.00	0.00	1.04	24.00	0.00
5.00a	2.08	50.00	0.00	1.04	24.00	0.00
10.00a	2.08	50.00	0.00	1.04	24.00	0.00
15.00a	2.08	50.00	0.00	1.04	24.00	0.00
20.00a	2.08	50.00	0.00	1.04	24.00	0.00
24.00a	2.08	50.00	0.00	1.04	24.00	0.00
28.00a	2.08	50.00	0.00	1.04	24.00	0.00
32.00a	2.08	50.00	0.00	1.04	24.00	0.00
36.00a	2.08	50.00	0.00	1.04	24.00	0.00
40.00a	2.08	50.00	0.00	1.04	24.00	0.00
44.00a	2.08	50.00	0.00	1.04	24.00	0.00
48.00a	2.08	50.00	0.00	1.04	24.00	0.00
52.00a	2.08	50.00	0.00	1.04	24.00	0.00
54.78a	2.08	0.00	0.00	2.08	24.00	0.00
...						
60.00a	2.08					

Distances in FEET.

3 M1A1 Tanks Still Water

Part: HULL Component: HULL.C Side: CL Effectiveness: 1.000

Origin Depth: 3.714 Trim: zero Heel: zero

HULL.C COMPONENT SECTIONS

Section Location	Baseline Depth	Section Area	Section TCtr	Section VCtr	Waterline Width	Waterline Ctr
60.00f	3.71					
56.95f	3.71	0.00	0.00	3.71	24.00	0.00
56.00f	3.71	17.15	0.00	3.36	24.00	0.00
52.00f	3.71	89.15	0.00	1.86	24.00	0.00
48.00f	3.71	89.15	0.00	1.86	24.00	0.00
44.00f	3.71	89.15	0.00	1.86	24.00	0.00
40.00f	3.71	89.15	0.00	1.86	24.00	0.00
36.00f	3.71	89.15	0.00	1.86	24.00	0.00
32.00f	3.71	89.15	0.00	1.86	24.00	0.00
28.00f	3.71	89.15	0.00	1.86	24.00	0.00
24.00f	3.71	89.15	0.00	1.86	24.00	0.00
20.00f	3.71	89.15	0.00	1.86	24.00	0.00
15.00f	3.71	89.15	0.00	1.86	24.00	0.00
10.00f	3.71	89.15	0.00	1.86	24.00	0.00
5.00f	3.71	89.15	0.00	1.86	24.00	0.00
0.00	3.71	89.15	0.00	1.86	24.00	0.00
5.00a	3.71	89.15	0.00	1.86	24.00	0.00
10.00a	3.71	89.15	0.00	1.86	24.00	0.00
15.00a	3.71	89.15	0.00	1.86	24.00	0.00
20.00a	3.71	89.15	0.00	1.86	24.00	0.00
24.00a	3.71	89.15	0.00	1.86	24.00	0.00
28.00a	3.71	89.15	0.00	1.86	24.00	0.00
32.00a	3.71	89.15	0.00	1.86	24.00	0.00
36.00a	3.71	89.15	0.00	1.86	24.00	0.00
40.00a	3.71	89.15	0.00	1.86	24.00	0.00
44.00a	3.71	89.15	0.00	1.86	24.00	0.00
48.00a	3.71	89.15	0.00	1.86	24.00	0.00
52.00a	3.71	89.15	0.00	1.86	24.00	0.00
56.00a	3.71	17.15	0.00	3.36	24.00	0.00
56.95a	3.71	0.00	0.00	3.71	24.00	0.00
60.00a	3.71					

Distances in FEET.

2 M1A1 Tanks Still Water

Part: HULL Component: HULL.C Side: CL Effectiveness: 1.000

Origin Depth: 2.907 Trim: zero Heel: zero

HULL.C COMPONENT SECTIONS

Section Location	Baseline Depth	Section Area	Section TCtr	Section VCtr	Waterline Width	Waterline Ctr
60.00f	2.91					
...						
55.88f	2.91	0.00	0.00	2.91	24.00	0.00
52.00f	2.91	69.77	0.00	1.45	24.00	0.00
48.00f	2.91	69.77	0.00	1.45	24.00	0.00
44.00f	2.91	69.77	0.00	1.45	24.00	0.00
40.00f	2.91	69.77	0.00	1.45	24.00	0.00
36.00f	2.91	69.77	0.00	1.45	24.00	0.00
32.00f	2.91	69.77	0.00	1.45	24.00	0.00
28.00f	2.91	69.77	0.00	1.45	24.00	0.00
24.00f	2.91	69.77	0.00	1.45	24.00	0.00
20.00f	2.91	69.77	0.00	1.45	24.00	0.00
15.00f	2.91	69.77	0.00	1.45	24.00	0.00
10.00f	2.91	69.77	0.00	1.45	24.00	0.00
5.00f	2.91	69.77	0.00	1.45	24.00	0.00
0.00	2.91	69.77	0.00	1.45	24.00	0.00
5.00a	2.91	69.77	0.00	1.45	24.00	0.00
10.00a	2.91	69.77	0.00	1.45	24.00	0.00
15.00a	2.91	69.77	0.00	1.45	24.00	0.00
20.00a	2.91	69.77	0.00	1.45	24.00	0.00
24.00a	2.91	69.77	0.00	1.45	24.00	0.00
28.00a	2.91	69.77	0.00	1.45	24.00	0.00
32.00a	2.91	69.77	0.00	1.45	24.00	0.00
36.00a	2.91	69.77	0.00	1.45	24.00	0.00
40.00a	2.91	69.77	0.00	1.45	24.00	0.00
44.00a	2.91	69.77	0.00	1.45	24.00	0.00
48.00a	2.91	69.77	0.00	1.45	24.00	0.00
52.00a	2.91	69.77	0.00	1.45	24.00	0.00
55.88a	2.91	0.00	0.00	2.91	24.00	0.00
...						
60.00a	2.91					

Distances in FEET.

3 M1A1 Tanks on L/20 Trochoidal Wave

HULL.C COMPONENT SECTIONS

Section Location	Baseline Depth	Wave Height	Wave +Heel	Section Area	Section TCtr	Section VCtr	Waterline Width	Waterline Ctr
60.00f	4.01	3.00	0.00	24.15	0.00	6.50	24.00	0.00
56.00f	4.01	2.91	0.00	93.95	0.00	4.96	24.00	0.00
52.00f	4.01	2.64	0.00	159.59	0.00	3.32	24.00	0.00
48.00f	4.01	2.23	0.00	149.67	0.00	3.12	24.00	0.00
44.00f	4.01	1.70	0.00	137.05	0.00	2.86	24.00	0.00
40.00f	4.01	1.11	0.00	122.71	0.00	2.56	24.00	0.00
36.00f	4.01	0.48	0.00	107.55	0.00	2.24	24.00	0.00
32.00f	4.01	-0.16	0.00	92.39	0.00	1.92	24.00	0.00
28.00f	4.01	-0.76	0.00	77.88	0.00	1.62	24.00	0.00
24.00f	4.01	-1.32	0.00	64.51	0.00	1.34	24.00	0.00
20.00f	4.01	-1.81	0.00	52.67	0.00	1.10	24.00	0.00
15.00f	4.01	-2.32	0.00	40.46	0.00	0.84	24.00	0.00
10.00f	4.01	-2.69	0.00	31.48	0.00	0.66	24.00	0.00
5.00f	4.01	-2.92	0.00	25.99	0.00	0.54	24.00	0.00
0.00	4.01	-3.00	0.00	24.15	0.00	0.50	24.00	0.00
5.00a	4.01	-2.92	0.00	25.99	0.00	0.54	24.00	0.00
10.00a	4.01	-2.69	0.00	31.48	0.00	0.66	24.00	0.00
15.00a	4.01	-2.32	0.00	40.46	0.00	0.84	24.00	0.00
20.00a	4.01	-1.81	0.00	52.67	0.00	1.10	24.00	0.00
24.00a	4.01	-1.32	0.00	64.51	0.00	1.34	24.00	0.00
28.00a	4.01	-0.76	0.00	77.88	0.00	1.62	24.00	0.00
32.00a	4.01	-0.16	0.00	92.39	0.00	1.92	24.00	0.00
36.00a	4.01	0.48	0.00	107.55	0.00	2.24	24.00	0.00
40.00a	4.01	1.11	0.00	122.71	0.00	2.56	24.00	0.00
44.00a	4.01	1.70	0.00	137.05	0.00	2.86	24.00	0.00
48.00a	4.01	2.23	0.00	149.67	0.00	3.12	24.00	0.00
52.00a	4.01	2.64	0.00	159.59	0.00	3.32	24.00	0.00
56.00a	4.01	2.91	0.00	93.95	0.00	4.96	24.00	0.00
60.00a	4.01	3.00	0.00	24.15	0.00	6.50	24.00	0.00

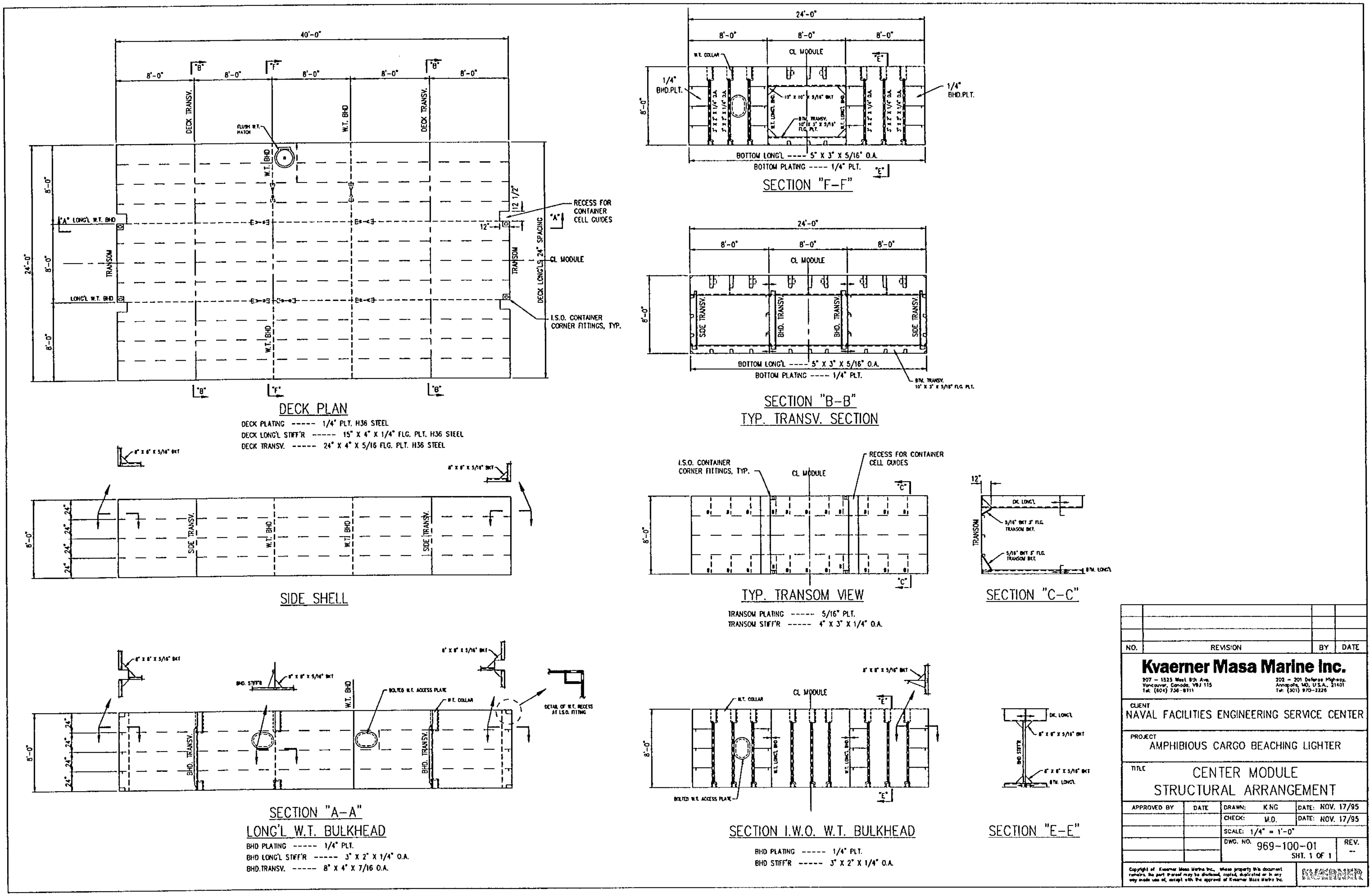
Distances in FEET.---------------------------Wave heel angles in degrees.

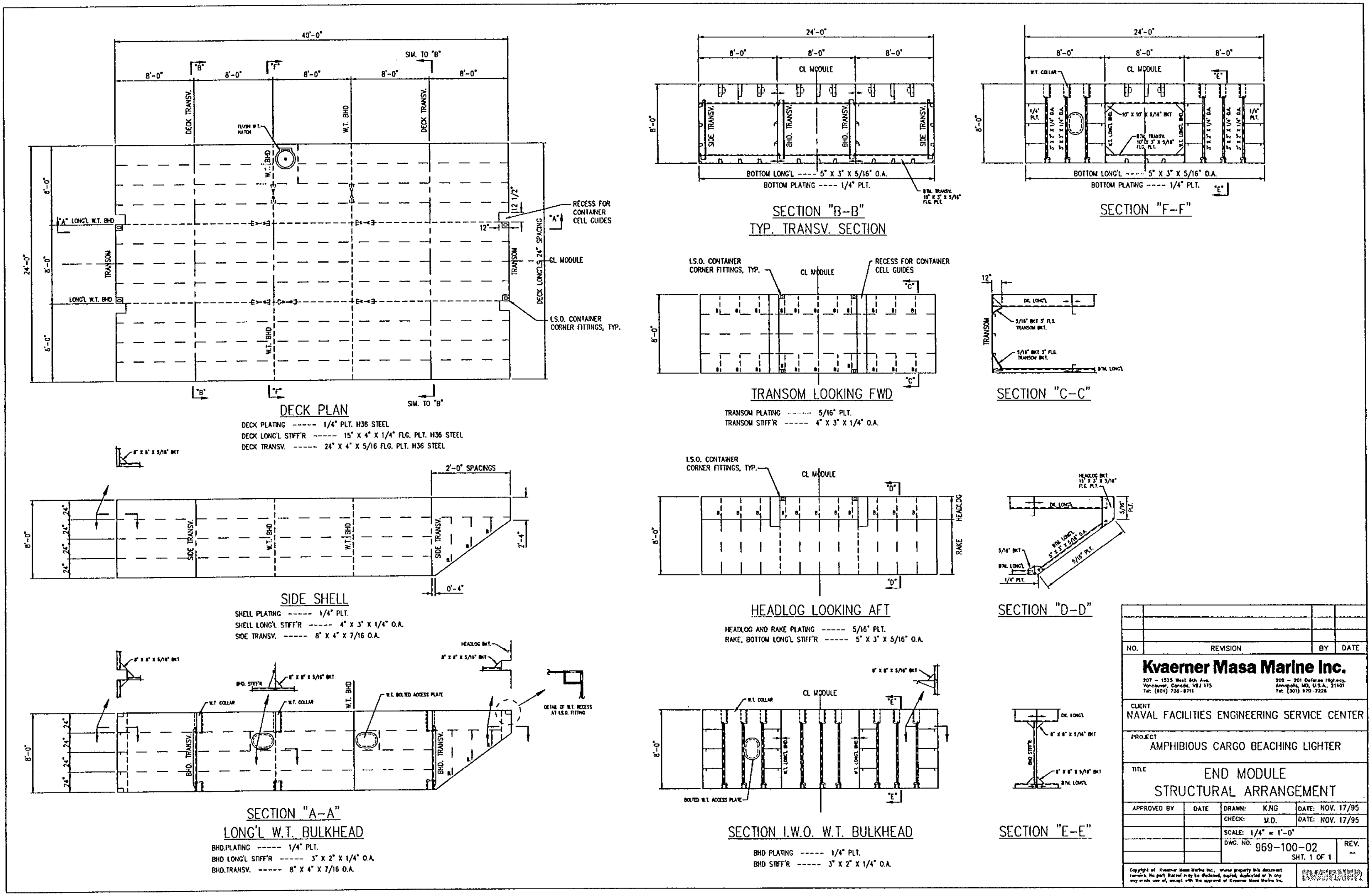
2 M1A1 Tanks on L/20 Trochoidal Wave

HULL.C COMPONENT SECTIONS

Section Location	Baseline Depth	Wave Height	Wave +Heel	Section Area	Section TCtr	Section VCtr	Waterline Width	Waterline Ctr
60.00f	2.84	-3.00	0.00					
...								
52.04f	2.84	-2.81	0.00	0.00	0.00	0.03	24.00	0.00
52.00f	2.84	-2.80	0.00	0.83	0.00	0.02	24.00	0.00
48.00f	2.84	-2.56	0.00	6.64	0.00	0.14	24.00	0.00
44.00f	2.84	-2.23	0.00	14.63	0.00	0.30	24.00	0.00
40.00f	2.84	-1.81	0.00	24.65	0.00	0.51	24.00	0.00
36.00f	2.84	-1.32	0.00	36.49	0.00	0.76	24.00	0.00
32.00f	2.84	-0.76	0.00	49.85	0.00	1.04	24.00	0.00
28.00f	2.84	-0.16	0.00	64.37	0.00	1.34	24.00	0.00
24.00f	2.84	0.48	0.00	79.53	0.00	1.66	24.00	0.00
20.00f	2.84	1.11	0.00	94.68	0.00	1.97	24.00	0.00
15.00f	2.84	1.84	0.00	112.38	0.00	2.34	24.00	0.00
10.00f	2.84	2.45	0.00	127.00	0.00	2.65	24.00	0.00
5.00f	2.84	2.86	0.00	136.71	0.00	2.85	24.00	0.00
0.00	2.84	3.00	0.00	140.12	0.00	2.92	24.00	0.00
5.00a	2.84	2.86	0.00	136.71	0.00	2.85	24.00	0.00
10.00a	2.84	2.45	0.00	127.00	0.00	2.65	24.00	0.00
15.00a	2.84	1.84	0.00	112.38	0.00	2.34	24.00	0.00
20.00a	2.84	1.11	0.00	94.68	0.00	1.97	24.00	0.00
24.00a	2.84	0.48	0.00	79.53	0.00	1.66	24.00	0.00
28.00a	2.84	-0.16	0.00	64.37	0.00	1.34	24.00	0.00
32.00a	2.84	-0.76	0.00	49.85	0.00	1.04	24.00	0.00
36.00a	2.84	-1.32	0.00	36.49	0.00	0.76	24.00	0.00
40.00a	2.84	-1.81	0.00	24.65	0.00	0.51	24.00	0.00
44.00a	2.84	-2.23	0.00	14.63	0.00	0.30	24.00	0.00
48.00a	2.84	-2.56	0.00	6.64	0.00	0.14	24.00	0.00
52.00a	2.84	-2.80	0.00	0.83	0.00	0.02	24.00	0.00
52.04a	2.84	-2.81	0.00	0.00	0.00	0.03	24.00	0.00
...								
60.00a	2.84	-3.00	0.00					

Distances in FEET.----------------------------Wave heel angles in degrees.


DECK PLAN
DECK PLATING ----- 1/4" PLT. H36 STEEL
DECK LONG'L STIFF'R ----- 15" X 4" X 1/4" FLG. PLT. H36 STEEL
DECK TRANSV. ----- 24" X 4" X 5/16 FLG. PLT. H36 STEEL
RECESS FOR CONTAINER CELL GUIDES
I.S.O. CONTAINER CORNER FITTINGS, TYP.
DECK LONG'L'S 24" SPACING
CL MODULE
TRANSOM
W.T. BHD
DECK TRANSV.
FLUSH W.T. HATCH
"A" LONG'L W.T. BHD
LONG'L W.T. BHD
40'-0"
24'-0"
8'-0"
12 1/2"
12"
SIDE SHELL
SIDE TRANSV.
SECTION "A-A"
LONG'L W.T. BULKHEAD
BHD PLATING ----- 1/4" PLT.
BHD LONG'L STIFF'R ----- 3" X 2" X 1/4" O.A.
BHD.TRANSV. ----- 8" X 4" X 7/16 O.A.
BHD. TRANSV.
BOLTED W.T. ACCESS PLATE
W.T. COLLAR
DETAIL OF W.T. RECESS AT I.S.O. FITTING
SECTION "F-F"
1/4" BHD.PLT.
BOTTOM LONG'L ---- 5" X 3" X 5/16" O.A.
BOTTOM PLATING ---- 1/4" PLT.
SECTION "B-B"
TYP. TRANSV. SECTION
BHD. TRANSV.
SIDE TRANSV.
TYP. TRANSOM VIEW
TRANSOM PLATING ----- 5/16" PLT.
TRANSOM STIFF'R ----- 4" X 3" X 1/4" O.A.
SECTION "C-C"
DK. LONG'L
BTM. LONG'L
SECTION I.W.O. W.T. BULKHEAD
BHD PLATING ----- 1/4" PLT.
BHD STIFF'R ----- 3" X 2" X 1/4" O.A.
SECTION "E-E"
NO.
REVISION
BY
DATE
Kvaerner Masa Marine Inc.
CLIENT
NAVAL FACILITIES ENGINEERING SERVICE CENTER
PROJECT
AMPHIBIOUS CARGO BEACHING LIGHTER
TITLE
CENTER MODULE
STRUCTURAL ARRANGEMENT
APPROVED BY
DATE
DRAWN: KNG
DATE: NOV. 17/95
CHECK: M.O.
DATE: NOV. 17/95
SCALE: 1/4" = 1'-0"
DWG. NO. 969-100-01
SHT. 1 OF 1
REV.
-


DECK PLAN
DECK PLATING ----- 1/4" PLT. H36 STEEL
DECK LONG'L STIFF'R ----- 15" X 4" X 1/4" FLG. PLT. H36 STEEL
DECK TRANSV. ----- 24" X 4" X 5/16 FLG. PLT. H36 STEEL
RECESS FOR CONTAINER CELL GUIDES
I.S.O. CONTAINER CORNER FITTINGS, TYP.
FLUSH W.T. HATCH
SIDE SHELL
SHELL PLATING ----- 1/4" PLT.
SHELL LONG'L STIFF'R ----- 4" X 3" X 1/4" O.A.
SIDE TRANSV. ----- 8" X 4" X 7/16 O.A.
SECTION "A-A"
LONG'L W.T. BULKHEAD
BHD.PLATING ----- 1/4" PLT.
BHD LONG'L STIFF'R ----- 3" X 2" X 1/4" O.A.
BHD.TRANSV. ----- 8" X 4" X 7/16 O.A.
SECTION "B-B"
TYP. TRANSV. SECTION
BOTTOM LONG'L ----- 5" X 3" X 5/16" O.A.
BOTTOM PLATING ----- 1/4" PLT.
SECTION "F-F"
TRANSOM LOOKING FWD
TRANSOM PLATING ----- 5/16" PLT.
TRANSOM STIFF'R ----- 4" X 3" X 1/4" O.A.
SECTION "C-C"
HEADLOG LOOKING AFT
HEADLOG AND RAKE PLATING ----- 5/16" PLT.
RAKE, BOTTOM LONG'L STIFF'R ----- 5" X 3" X 5/16" O.A.
SECTION "D-D"
SECTION I.W.O. W.T. BULKHEAD
BHD PLATING ----- 1/4" PLT.
BHD STIFF'R ----- 3" X 2" X 1/4" O.A.
SECTION "E-E"
NO. | REVISION | BY | DATE
Kvaerner Masa Marine Inc.
CLIENT NAVAL FACILITIES ENGINEERING SERVICE CENTER
PROJECT AMPHIBIOUS CARGO BEACHING LIGHTER
TITLE END MODULE STRUCTURAL ARRANGEMENT
APPROVED BY | DATE | DRAWN: K.NG | DATE: NOV. 17/95
CHECK: M.D. | DATE: NOV. 17/95
SCALE: 1/4" = 1'-0"
DWG. NO. 969-100-02 SHT. 1 OF 1 REV. -

APPENDIX E

Weight Report

FINAL WEIGHT R[illegible]ORT
1/7

END [illegible]EIGHT
H36 STEEL DECK

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
100	STRUCTURE													
111	SHELL PLATING													
	BOTTOM SHELL 1/4" PL	10.20	lb./ ft^2	776.00	ft^2	1	776	7915.2	0	0	23.8	0	0	188619.2
	RAKE PLATING 5/16" PL	12.75	lb./ ft^2	228.75	ft^2	1	228.8	2916.6	2.83	0	3.83	8253.872	0	11170.43
	SIDESHELL 1/4" PL	10.20	lb./ ft^2	298.30	ft^2	2	596.6	6085.3	4.15	0	21.3	25254.08	0	129434.8
	TRANSOM PLATING 5/16" PL	12.75	lb./ ft^2	224.00	ft^2	1	224	2856	4	0	40	11424	0	114240
	HEAD LOG PLATING 5/16" PL	12.75	lb./ ft^2	65.33	ft^2	1	65.33	832.96	6.83	0	0	5689.1	0	0
	SIDE SHELL/ TRANSOM BKT 5/16" PL	12.75	lb./ ft^2	0.22	ft^2	6	1.32	16.83	4	0	40	67.32	0	673.2
	SIDE SHELL/ HEADING BKT 5/16" PL	12.75	lb./ ft^2	0.22	ft^2	2	0.44	5.61	6	0	0	33.66	0	0
116	LONGITUDINAL FRAMING													
	BOTTOM LONG'L 5"x3"x5/16" O.A.	8.20	lb/ft	32.33	ft	9	291	2386	0.3	0	23.8	715.7862	0	56857.28
	RAKE LONG'L 5"x3"x5/16" O.A.	8.20	lb/ft	9.50	ft	9	85.5	701.1	2.83	0	3.83	1984.113	0	2685.213
	SHELL LONG'L 4"x3"x1/4" O.A.	5.80	lb/ft	40.00	ft	2	80	464	6	0	20	2784	0	9280
	SHELL LONG'L 4"x3"x1/4" O.A.	5.80	lb/ft	32.00	ft	4	128	742.4	3	0	24	2227.2	0	17817.6
	TRANSOM BKT 5/16" PL (TOP)	12.75	lb/ft^2	1.30	ft^2	21	27.3	348.08	7	0	39.5	2436.525	0	13748.96
	TRANSOM BKT 5/16" PL (BOTTOM)	12.75	lb/ft^2	1.30	ft^2	9	11.7	149.18	0.75	0	39.5	111.8813	0	5892.413
	HEADLOG BKT 5/16" PL	12.75	lb/ft^2	4.10	ft^2	21	86.1	1097.8	7	0	0.75	7684.425	0	823.3313
117	TRANSVERSE FRAMING													
	BOTTOM TRANSV. 10"x3"x5/16" FLG PL	13.81	lb/ft	24.00	ft	2	48	662.88	0.71	0	20	470.6448	0	13257.6
	BOTTOM TRANSV. 10"x3"x5/16" FLG PL	13.81	lb/ft	8.00	ft	1	8	110.48	0.71	0	24	78.4408	0	2651.52
	SIDE TRANSV. 8"x4"x7/16" O.A.	17.20	lb/ft	6.00	ft	4	24	412.8	4	0	20	1651.2	0	8256
	SHELL TRANSV. STIFF 4"x3"x1/4" O.A.	5.80	lb/ft	8.50	ft	2	17	98.6	5	0	4	493	0	394.4
	TRANSOM FRAMING 4"x3"x1/4" O.A.	5.80	lb/ft	24.00	ft	3	72	417.6	4	0	39.9	1670.4	0	16662.24
	TRANSOM HORIZONTAL BKT 5/16"	12.75	lb/ft^2	0.45	ft^2	12	5.4	68.85	4	0	39.5	275.4	0	2719.575
	SHELL/ TRANSOM BKT 5/16"	12.75	lb/ft^2	0.45	ft^2	6	2.7	34.425	4	0	39.5	137.7	0	1359.788

2/7

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
	HEADLOG HOR. BKT. 5/16"	12.75	lb/ft^2	0.45	ft^2	6	2.7	34.425	6	0	0.25	206.55	0	8.60625
	BTM TRANSV. BKT 5/16"	12.75	lb/ft^2	0.70	ft^2	2	1.4	17.85	1.1	0	24	19.635	0	428.4
121	LONG'L STRUCTURAL BHD													
	BHD. PLATING 1/4" PL	10.20	lb/ft^2	298.30	ft^2	2	596.6	6085.3	4.15	0	21.3	25254.08	0	129434.8
	BHD. LONG'L 3"x2"x1/4" O.A.	4.10	lb/ft	40.00	ft	2	80	328	6	0	20	1968	0	6560
	BHD. LONG'L 3"x2"x1/4" O.A.	4.10	lb/ft	32.00	ft	4	128	524.8	3	0	24	1574.4	0	12595.2
	LONG'L END BKT 5/16" PL	12.75	lb/ft^2	0.22	ft^2	6	1.32	16.83	2	0	38.8	33.66	0	652.1625
	LONG'L END BKT FWD 5/16" PL	12.75	lb/ft^2	0.22	ft^2	2	0.44	5.61	6	0	1.25	33.66	0	7.0125
	BHD. TRANSV. 8"x4"x7/16" O.A.	17.20	lb/ft	6.00	ft	4	24	412.8	4	0	20	1651.2	0	8256
	BHD/ TRANSV/ STIFF 3"x2"x1/4" O.A.	4.10	lb/ft	8.50	ft	2	17	69.7	5	0	4	348.5	0	278.8
	BHD/ TRANSV/ STIFF BK 5/16"	12.75	lb/ft^2	0.22	ft^2	6	1.32	16.83	2.25	0	4	37.8675	0	67.32
122	TRANSV. STRUCTURAL BULKHEAD													
	PARTIAL WING BHD. 1/4" PL	10.20	lb/ft^2	64.00	ft^2	2	128	1305.6	4	0	24	5222.4	0	31334.4
	PARTIAL BHD. STIFF 3"x2"x1/4" O.A.	4.10	lb/ft	6.59	ft	6	39.54	162.11	3.75	0	24	607.9275	0	3890.736
	BOTTOM BKT 5/16" (COMBINED)	12.75	lb/ft^2	0.45	ft^2	6	2.7	34.425	0.6	0	24	20.655	0	826.2
	TOP BKT 5/16" (COMBINED)	12.75	lb/ft^2	1.00	ft^2	6	6	76.5	6.7	0	24	512.55	0	1836
	HOR. BKT 5/16" (COMBINED)	12.75	lb/ft^2	0.90	ft^2	12	10.8	137.7	4	0	24	550.8	0	3304.8
							0	0				0	0	0
	FULL TRANSV. BHD 1/4" PLT	10.20	lb/ft^2	192.00	ft^2	1	192	1958.4	4	0	16	7833.6	0	31334.4
	BHD STIFF 3"x2"x1/4" O.A.	4.10	lb/ft	6.59	ft	9	59.31	243.17	3.75	0	16	911.8913	0	3890.736
	BHD BOTTOM BKT 5/16" (COMBINED)	12.75	lb/ft^2	0.45	ft^2	9	4.05	51.638	0.6	0	16	30.9825	0	826.2
	TOP BKT 5/16" (COMBINED)	12.75	lb/ft^2	1.00	ft^2	9	9	114.75	6.7	0	16	768.825	0	1836
	HOR. BKT 5/16" (COMBINED)	12.75	lb/ft^2	0.90	ft^2	12	10.8	137.7	4	0	16	550.8	0	2203.2
131	MAIN DECK													
	MAIN DECK PLATING 1/4" PL	10.20	lb/ft^2	960.00	ft^2	1	960	9792	8	0	20	78336	0	195840

END WEIGHT
H36 STEEL DECK

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SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
	DK LONG'L 15"x4"x5/16" FLG. PL	16.00	lb/ft	40.00	ft	9	360	5760	7.5	0	20	43200	0	115200
	FULL DECK TRANSV 24"x4"x1/4" FLG PL	25.00	lb/ft	24.00	ft	2	48	1200	7.25	0	20	8700	0	24000
	PARTIAL DK TRANSV. 24"x4"x1/4" FLG.PL	25.00	lb/ft	8.00	ft	1	8	200	7.25	0	24	1450	0	4800
	DK TRANSV. BKT 5/16" PLT	12.75	lb/ft^2	0.70	ft^2	2	1.4	17.85	6.25	0	24	111.5625	0	428.4
167	WT HATCH	150.0	lb	1.00	ea.	1	1	150	8	10.5	22.5	1200	1575	3375
100	TOTAL							57027	4.44	0	20.6	253378.3	0	1176383

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SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
600														
611	MOORING ANCHORING 'D' RINGS	10	lb	1	ea.	2	2	20	8	0	6	160	0	120
	LIFTING 'D' RINGS	15	lb	1	ea.	4	4	60	8	0	20	480	0	1200
	LASHING 'D' RINGS	15	lb	1	ea.	4	4	60	5	0	20	300	0	1200
	ISO CONTAINER CORNER FITTINGS	27	lb	1	ea.	6	6	162	5.3	0	13.3	858.6	0	2154.6
623	VERTICAL LADDER	60	lb	1	ea.	1	1	60	4	10.5	23	240	630	1380
631	PAINT	855	lb	1	ea.	1	1	855	4.44	0	20.6	3796.2	0	17613
673	CARGO TIE DOWN CLOVERLEAF FITTINGS	17	lb	1	ea.	18	18	306	8	0	20	2448	0	6120
600	TOTAL							1523	5.44	0.41	19.6	8282.8	630	29787.6
	TOTAL FOR ALL GROUPS							58550	4.47	0.01	20.6	261661.1	630	1206170

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H36 STEEL DECK (8 ft Transverse spacing)

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
100	STRUCTURE													
111	SHELL PLATING													
	BOTTOM SHELL 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	0	0	20	0	0	195840
	SIDE SHELL 1/4" PL	10.2	lb/ft^2	320	ft^2	2	640	6528	4	0	20	26112	0	130560
	TRANSOM 5/16" PL	12.8	lb/ft^2	192	ft^2	2	384	4896	4	0	20	19584	0	97920
	SIDE SHELL/TRANSOM BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	12	2.64	33.66	4	0	20	134.64	0	673.2
116	LONG'L FRAMING													
	BOTTOM LONG'L 5"x3"x5/16" OA	8.2	lb/ft	40	ft	9	360	2952	0.3	0	20	885.6	0	59040
	SIDE LONG'L 4"x3"x1/4" OA	5.8	lb/ft	40	ft	6	240	1392	4	0	20	5568	0	27840
	TRANSOM BKT 5/16" PL (TOP)	12.8	lb/ft^2	1.3	ft^2	38	49.4	629.85	7	0	20	4408.95	0	12597
	TRANSOM BKT 5/16" PL (BTM)	12.8	lb/ft^2	1.3	ft^2	18	23.4	298.35	1	0	20	298.35	0	5967
117	TRANSVERSE FRAMING													
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	24	ft	2	48	662.88	0.71	0	20	470.6448	0	13257.6
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	8	ft	1	8	110.48	0.71	0	24	78.4408	0	2651.52
	SIDE TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256
	TRANSOM FRAMING 4"x3"x1/4" OA	5.8	lb/ft	24	ft	6	144	835.2	4	0	20	3340.8	0	16704
	TRANSOM HORIZONTAL BKT 5/16"	12.8	lb/ft^2	0.45	ft^2	24	10.8	137.7	4	0	20	550.8	0	2754
	BTM TRANSV BKT 5/16"	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	1.1	0	24	19.635	0	428.4
121	LONG'L STRUCTURAL BULKHEAD													
	BHD PLATING 1/4" PL	10.2	lb/ft	320	ft	2	640	6528	4	0	20	26112	0	130560
	BHD LONG'L 3"x2"x1/4" OA	4.1	lb/ft	38	ft	6	228	934.8	4	0	20	3739.2	0	18696
	LONG'L END BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	6	1.32	16.83	4	0	20	67.32	0	336.6
	BHD TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256

H36 STEEL DECK (8 ft Transverse spacing)

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SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
122	TRANSV STRUCTURAL BULKHEAD													
	PARTIAL BHD 1/4" PL	10.2	lb/ft^2	64	ft^2	2	128	1305.6	4	0	24	5222.4	0	31334.4
	PARTIAL BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	6	39.54	162.11	3.75	0	24	607.9275	0	3890.736
	BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	6	2.7	34.425	0.6	0	24	20.655	0	826.2
	TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	6	6	76.5	6.7	0	24	512.55	0	1836
	HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	24	550.8	0	3304.8
	FULL TRANSV BHD 1/4" PL	10.2	lb/ft^2	192	ft^2	1	192	1958.4	4	0	16	7833.6	0	31334.4
	- BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	9	59.31	243.17	3.75	0	16	911.8913	0	3890.736
	- BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	9	4.05	51.638	0.6	0	16	30.9825	0	826.2
	- TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	9	9	114.75	6.7	0	16	768.825	0	1836
	- HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	16	550.8	0	2203.2
131	MAIN DK													
	MAIN DK PLATING 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	8	0	20	78336	0	195840
	DK LONG'L 15"x4"x5/16" FLG PL	16	lb/ft	40	ft	9	360	5760	7.5	0	20	43200	0	115200
	FULL DK TRANSV 24"x4"x1/4" FLG PL	25	lb/ft	24	ft	2	48	1200	7.25	0	20	8700	0	24000
	PARTIAL DECK TRANSV 24"x4"x1/4" FLG PL	25	lb/ft	8	ft	1	8	200	7.25	0	24	1450	0	4800
	DK TRANSV BKT 5/16" PLT	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	6.25	0	24	111.5625	0	428.4
169	WT HATCH	150	lb	1	ea.	1	1	150	8	10.5	22.5	1200	1575	3375
100	TOTAL							57933	4.22	0.03	20	244680.8	1575	1157263

H36 STEEL DECK (8 ft Transverse spacing)

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SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
600														
611	MOORING ANCHORING 'D' RINGS	10	lb	1	ea.	6	6	60	8	0	20	480	0	1200
	LIFTING 'D' RINGS	15	lb	1	ea.	4	4	60	8	0	20	480	0	1200
	LASHING 'D' RINGS	15	lb	1	ea.	4	4	60	5	0	20	300	0	1200
	ISO CONTAINER CORNER FITTINGS	27	lb	1	ea.	8	8	216	4	0	20	864	0	4320
623	VERTICAL LADDER	60	lb	1	ea.	1	1	60	4	10.5	23	240	630	1380
631	PAINT	869	lb	1	ea.	1	1	869	4.22	0.03	20	3667.18	26.07	17380
673	CARGO TIE DOWN CLOVERLEAF FITTINGS	17	lb	1	ea.	18	18	306	8	0	20	2448	0	6120
600	TOTAL							1631	5.2	0.4	20.1	8479.18	656.07	32800
	TOTAL FOR ALL GROUPS							59564	4.25	0.04	20	253160	2231.07	1190063

AMPHIBIOUS CARGO BEACHING LIGHTER DEVELOPMENT - PHASE I

FINAL REPORT

APPENDIX E

The following weight sheets document the weight of the Center moudel for various weight trade-offs made in structural arrangments. In summary these are:

- Ordinary Strength steel deck, longitudinally framed, 12 in stiff spacing 70872#
- Ordinary Strength steel deck, transversely framed 82751#
- High Strength steel deck, longitudinally framed, 8 ft web spacing 12 inch stiff spacing 63529#
- High Strength steel deck, corrugated panels 60539#
- High Strength steel deck, longitudinally framed,4 ft web spacing, 12 inch stiff spacing 64419#
- High Strength steel deck, longitudinally framed, 8 ft web spacing, 24 inch stiff spacing (final arrangement) 57933#

CENTERWT
-Ordinary strength steel
-Longitudinally framed
-12" Deck beam spacing

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
100	STRUCTURE													
111	SHELL PLATING													
	BOTTOM SHELL 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	0	0	20	0	0	195840
	SIDE SHELL 1/4" PL	10.2	lb/ft^2	320	ft^2	2	640	6528	4	0	20	26112	0	130560
	TRANSOM 5/16" PL	12.8	lb/ft^2	224	ft^2	2	448	5712	4	0	20	22848	0	114240
	SIDE SHELL/TRANSOM BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	12	2.64	33.66	4	0	20	134.64	0	673.2
116	LONG'L FRAMING													
	BOTTOM LONG'L 5"x3"x5/16" OA	8.2	lb/ft	40	ft	9	360	2952	0.3	0	20	885.6	0	59040
	SIDE LONG'L 4"x3"x1/4" OA	5.8	lb/ft	40	ft	6	240	1392	4	0	20	5568	0	27840
	TRANSOM BKT 5/16" PL (TOP)	12.8	lb/ft^2	1.3	ft^2	38	49.4	629.85	7	0	20	4408.95	0	12597
	TRANSOM BKT 5/16" PL (BTM)	12.8	lb/ft^2	1.3	ft^2	18	23.4	298.35	1	0	20	298.35	0	5967
117	TRANSVERSE FRAMING													
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	24	ft	2	48	662.88	0.71	0	20	470.6448	0	13257.6
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	8	ft	1	8	110.48	0.71	0	24	78.4408	0	2651.52
	SIDE TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256
	TRANSVERSE FRAMING 4"x3"x1/4" OA	5.8	lb/ft	24	ft	6	144	835.2	4	0	20	3340.8	0	16704
	TRANSOM HORIZONTAL BKT 5/16"	12.8	lb/ft^2	0.45	ft^2	24	10.8	137.7	4	0	20	550.8	0	2754
	BTM TRANSV BKT 5/16"	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	1.1	0	24	19.635	0	428.4
121	LONG'L STRUCTURAL BULKHEAD													
	BHD PLATING 1/4" PL	10.2	lb/ft	320	ft	2	640	6528	4	0	20	26112	0	130560
	BHD LONG'L 3"x2"x1/4" OA	4.1	lb/ft	38	ft	6	228	934.8	4	0	20	3739.2	0	18696
	LONG'L END BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	6	1.32	16.83	4	0	20	67.32	0	336.6

CE[illegible]ERWT
-Ordinary strength steel
-Longitudinally framed
-12" Deck beam spacing

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
	BHD TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256
122	TRANSV STRUCTURAL BULKHEAD													
	PARTIAL BHD 1/4" PL	10.2	lb/ft^2	64	ft^2	2	128	1305.6	4	0	24	5222.4	0	31334.4
	PARTIAL BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	6	39.54	162.11	3.75	0	24	607.9275	0	3890.736
	BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	6	2.7	34.425	0.6	0	24	20.655	0	826.2
	TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	6	6	76.5	6.7	0	24	512.55	0	1836
	HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	24	550.8	0	3304.8
	FULL TRANSV BHD 1/4" PL	10.2	lb/ft^2	192	ft^2	1	192	1958.4	4	0	16	7833.6	0	31334.4
	- BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	9	59.31	243.17	3.75	0	16	911.8913	0	3890.736
	- BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	9	4.05	51.638	0.6	0	16	30.9825	0	826.2
	- TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	9	9	114.75	6.7	0	16	768.825	0	1836
	- HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	16	550.8	0	2203.2
131	MAIN DK													
	MAIN DK PLATING 5/16" PL	12.8	lb/ft^2	960	ft^2	1	960	12240	8	0	20	97920	0	244800
	DK LONG'L 12"x5"x5/16" FLG PL	18.1	lb/ft	40	ft	21	840	15170	7.25	0	20	109985.4	0	303408
	FULL DK TRANSV 24"x5"x5/16" FLG PL	30.8	lb/ft	24	ft	2	48	1478.9	6.75	0	20	9982.44	0	29577.6
	TRIPPING BKT 4x5/16" FB	4.25	lb/ft	1	ft	18	18	76.5	6.5	0	20	497.25	0	1530
	PARTIAL DECK TRANSV 24"x5"x5/16" FLG PL	30.8	lb/ft	8	ft	1	8	246.48	6.75	0	24	1663.74	0	5915.52
	TRIPPING BKT 4x5/16" FB	4.25	lb/ft	1	ft	3	3	12.75	6.5	0	24	82.875	0	306
	DK TRANSV BKT 5/16" PLT	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	5.75	0	24	102.6375	0	428.4
100	TOTAL							70872	4.73	0	20	335181.6	0	1415906

CENTERWT
-Transversely framed
-Ordinary strength deck
-24" Frame spacing

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
100	STRUCTURE													
111	SHELL PLATING													
	BOTTOM SHELL 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	0	0	20	0	0	195840
	SIDE SHELL 1/4" PL	10.2	lb/ft^2	320	ft^2	2	640	6528	4	0	20	26112	0	130560
	TRANSOM 5/16" PL	12.8	lb/ft^2	224	ft^2	2	448	5712	4	0	20	22848	0	114240
	SIDE SHELL/TRANSOM BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	12	2.64	33.66	4	0	20	134.64	0	673.2
116	LONG'L FRAMING													
	BOTTOM LONG'L 5"x3"x5/16" OA	8.2	lb/ft	40	ft	9	360	2952	0.3	0	20	885.6	0	59040
	SIDE LONG'L 4"x3"x1/4" OA	5.8	lb/ft	40	ft	6	240	1392	4	0	20	5568	0	27840
	TRANSOM BKT 5/16" PL (TOP)	12.8	lb/ft^2	1.3	ft^2	38	49.4	629.85	7	0	20	4408.95	0	12597
	TRANSOM BKT 5/16" PL (BTM)	12.8	lb/ft^2	1.3	ft^2	18	23.4	298.35	1	0	20	298.35	0	5967
117	TRANSVERSE FRAMING													
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	24	ft	2	48	662.88	0.71	0	20	470.6448	0	13257.6
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	8	ft	1	8	110.48	0.71	0	24	78.4408	0	2651.52
	SIDE TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256
	TRANSVERSE FRAMING 4"x3"x1/4" OA	5.8	lb/ft	24	ft	6	144	835.2	4	0	20	3340.8	0	16704
	TRANSOM HORIZONTAL BKT 5/16"	12.8	lb/ft^2	0.45	ft^2	24	10.8	137.7	4	0	20	550.8	0	2754
	BTM TRANSV BKT 5/16"	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	1.1	0	24	19.635	0	428.4
121	LONG'L STRUCTURAL BULKHEAD													
	BHD PLATING 1/4" PL	10.2	lb/ft	320	ft	2	640	6528	4	0	20	26112	0	130560
	BHD LONG'L 3"x2"x1/4" OA	4.1	lb/ft	38	ft	6	228	934.8	4	0	20	3739.2	0	18696
	LONG'L END BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	6	1.32	16.83	4	0	20	67.32	0	336.6

CENTERWT
-Transversely framed
-Ordinary strength deck
-24" Frame spacing

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
	BHD TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256
122	TRANSV STRUCTURAL BULKHEAD													
	PARTIAL BHD 1/4" PL	10.2	lb/ft^2	64	ft^2	2	128	1305.6	4	0	24	5222.4	0	31334.4
	PARTIAL BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	6	39.54	162.11	3.75	0	24	607.9275	0	3890.736
	BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	6	2.7	34.425	0.6	0	24	20.655	0	826.2
	TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	6	6	76.5	6.7	0	24	512.55	0	1836
	HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	24	550.8	0	3304.8
	FULL TRANSV BHD 1/4" PL	10.2	lb/ft^2	192	ft^2	1	192	1958.4	4	0	16	7833.6	0	31334.4
	- BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	9	59.31	243.17	3.75	0	16	911.8913	0	3890.736
	- BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	9	4.05	51.638	0.6	0	16	30.9825	0	826.2
	- TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	9	9	114.75	6.7	0	16	768.825	0	1836
	- HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	16	550.8	0	2203.2
131	MAIN DK-TRANSVERSE FRAMING													
	MAIN DK PLATING 7/16" PL	17.9	lb/ft^2	960	ft^2	1	960	17136	8	0	20	137088	0	342720
	DK BEAMS 16"x5"x3/8" FLG. PL.	26.8	lb/ft	24	ft	37	888	23772	7.55	0	20	179476.8	0	475435.2
	DK BEAMS 16"x5"x3/8" FLG. PL.	26.8	lb/ft	8	ft	1	8	214.16	7.55	0	24	1616.908	0	5139.84
100	TOTAL							82751	5.23	0	20	433128.9	0	1653235

CENTERWT
-H36 STEEL DECK
-8 ft Transverse spacing
-Longitudinally framed
-12" deck beam spacing

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
100	STRUCTURE													
111	SHELL PLATING													
	BOTTOM SHELL 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	0	0	20	0	0	195840
	SIDE SHELL 1/4" PL	10.2	lb/ft^2	320	ft^2	2	640	6528	4	0	20	26112	0	130560
	TRANSOM 5/16" PL	12.8	lb/ft^2	192	ft^2	2	384	4896	4	0	20	19584	0	97920
	SIDE SHELL/TRANSOM BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	12	2.64	33.66	4	0	20	134.64	0	673.2
116	LONG'L FRAMING													
	BOTTOM LONG'L 5"x3"x5/16" OA	8.2	lb/ft	40	ft	9	360	2952	0.3	0	20	885.6	0	59040
	SIDE LONG'L 4"x3"x1/4" OA	5.8	lb/ft	40	ft	6	240	1392	4	0	20	5568	0	27840
	TRANSOM BKT 5/16" PL (TOP)	12.8	lb/ft^2	1.3	ft^2	38	49.4	629.85	7	0	20	4408.95	0	12597
	TRANSOM BKT 5/16" PL (BTM)	12.8	lb/ft^2	1.3	ft^2	18	23.4	298.35	1	0	20	298.35	0	5967
117	TRANSVERSE FRAMING													
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	24	ft	2	48	662.88	0.71	0	20	470.6448	0	13257.6
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	8	ft	1	8	110.48	0.71	0	24	78.4408	0	2651.52
	SIDE TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256
	TRANSOM FRAMING 4"x3"x1/4" OA	5.8	lb/ft	24	ft	6	144	835.2	4	0	20	3340.8	0	16704
	TRANSOM HORIZONTAL BKT 5/16"	12.8	lb/ft^2	0.45	ft^2	24	10.8	137.7	4	0	20	550.8	0	2754
	BTM TRANSV BKT 5/16"	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	1.1	0	24	19.635	0	428.4
121	LONG'L STRUCTURAL BULKHEAD													
	BHD PLATING 1/4" PL	10.2	lb/ft	320	ft	2	640	6528	4	0	20	26112	0	130560
	BHD LONG'L 3"x2"x1/4" OA	4.1	lb/ft	38	ft	6	228	934.8	4	0	20	3739.2	0	18696
	LONG'L END BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	6	1.32	16.83	4	0	20	67.32	0	336.6

CENTERWT
-H36 STEEL DECK
-8 ft Transverse spacing
-Longitudinally framed
-12" deck beam spacing

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
	BHD TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256
122	TRANSV STRUCTURAL BULKHEAD													
	PARTIAL BHD 1/4" PL	10.2	lb/ft^2	64	ft^2	2	128	1305.6	4	0	24	5222.4	0	31334.4
	PARTIAL BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	6	39.54	162.11	3.75	0	24	607.9275	0	3890.736
	BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	6	2.7	34.425	0.6	0	24	20.655	0	826.2
	TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	6	6	76.5	6.7	0	24	512.55	0	1836
	HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	24	550.8	0	3304.8
	FULL TRANSV BHD 1/4" PL	10.2	lb/ft^2	192	ft^2	1	192	1958.4	4	0	16	7833.6	0	31334.4
	- BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	9	59.31	243.17	3.75	0	16	911.8913	0	3890.736
	- BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	9	4.05	51.638	0.6	0	16	30.9825	0	826.2
	- TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	9	9	114.75	6.7	0	16	768.825	0	1836
	- HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	16	550.8	0	2203.2
131	MAIN DK													
	MAIN DK PLATING 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	8	0	20	78336	0	195840
	DK LONG'L 9"x4"x5/16" FLG PL	13.8	lb/ft	40	ft	21	840	11600	7.5	0	20	87003	0	232008
	FULL DK TRANSV 18"x4"x5/16" FLG PL	23.3	lb/ft	24	ft	2	48	1118.9	7.25	0	20	8111.88	0	22377.6
	PARTIAL DECK TRANSV 18"x4"x5/16" FLG PL	23.4	lb/ft	8	ft	1	8	186.96	7.25	0	24	1355.46	0	4487.04
	DK TRANSV BKT 5/16" PLT	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	6.25	0	24	111.5625	0	428.4
100	TOTAL							63529	4.51	0	20	286601.1	0	1268761

CE... ERWT
-Corrugated panel
-High strength deck

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
100	STRUCTURE													
111	SHELL PLATING													
	BOTTOM SHELL 1/4" PL	10.2	lb/ft^2	1010	ft^2	1	1010	10302	0.13	0	20	1287.75	0	206040
	SIDE SHELL 1/4" PL	10.2	lb/ft^2	337	ft^2	2	673.6	6870.7	4	0	20	27482.88	0	137414.4
	TRANSOM 5/16" PL	12.8	lb/ft^2	224	ft^2	2	448	5712	4	0	20	22848	0	114240
	SIDE SHELL/TRANSOM BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	12	2.64	33.66	4	0	20	134.64	0	673.2
116	LONG'L FRAMING													
	TRANSOM BKT 5/16" PL (TOP)	12.8	lb/ft^2	1.3	ft^2	38	49.4	629.85	7	0	20	4408.95	0	12597
	TRANSOM BKT 5/16" PL (BTM)	12.8	lb/ft^2	1.3	ft^2	18	23.4	298.35	1	0	20	298.35	0	5967
117	TRANSVERSE FRAMING													
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	24	ft	2	48	662.88	0.8	0	20	530.304	0	13257.6
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	8	ft	1	8	110.48	0.8	0	24	88.384	0	2651.52
	BOTTOM TRANSV FILLER PL 5/16"x5" F.B.	5.31	lb/ft	1.6	ft	10	16	84.96	0.2	0	20	16.992	0	1699.2
	BOTTOM TRANSV FILLER PL 5/16"x5" F.B.	5.31	lb/ft	1.6	ft	2	3.2	16.992	0.2	0	24	3.3984	0	407.808
	SIDE TRANSV 6"x3.5"x5/16" OA	9.8	lb/ft	6	ft	4	24	235.2	4	0	20	940.8	0	4704
	TRANSVERSE FRAMING 4"x3"x1/4" OA	5.8	lb/ft	24	ft	6	144	835.2	4	0	20	3340.8	0	16704
	TRANSOM HORIZONTAL BKT 5/16"	12.8	lb/ft^2	0.45	ft^2	24	10.8	137.7	4	0	20	550.8	0	2754
	BTM TRANSV BKT 5/16"	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	1.1	0	24	19.635	0	428.4
	BTM TRANSOM BKT HEADER 4"x5/16" F.B.	4.25	lb/ft	24	ft	2	48	204	0.25	0	20	51	0	4080
121	LONG'L STRUCTURAL BULKHEAD													
	BHD PLATING 1/4" PL	10.2	lb/ft^2	337	ft^2	2	673.6	6870.7	4	0	20	27482.88	0	137414.4
	BHD TRANSV 6"x3.5"x5/16" OA	9.8	lb/ft	6	ft	4	24	235.2	4	0	20	940.8	0	4704

CEN ι ERWT
-Corrugated panel
-High strength deck

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
122	TRANSV STRUCTURAL BULKHEAD													
	PARTIAL BHD 1/4" PL	10.2	lb/ft^2	64	ft^2	2	128	1305.6	4	0	24	5222.4	0	31334.4
	PARTIAL BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	6	39.54	162.11	3.75	0	24	607.9275	0	3890.736
	BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	6	2.7	34.425	0.6	0	24	20.655	0	826.2
	TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	6	6	76.5	6.7	0	24	512.55	0	1836
	HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	24	550.8	0	3304.8
	STIFF BOTTOM BKT HEADER	4.25	lb/ft	16	ft	2	32	136	0.2	0	24	27.2	0	3264
	FULL BHD 1/4" PL	10.2	lb/ft^2	192	ft^2	1	192	1958.4	4	0	16	7833.6	0	31334.4
	- BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	9	59.31	243.17	3.75	0	16	911.8913	0	3890.736
	- BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	9	4.05	51.638	0.6	0	16	30.9825	0	826.2
	- TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	9	9	114.75	6.7	0	16	768.825	0	1836
	- HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	16	550.8	0	2203.2
	BTM STIFF BKT. HEADER 4"x5/16" F.B.	4.25	lb/ft	24	ft	2	48	204	2	0	16	408	0	3264
131	MAIN DK													
	MAIN DK PLATING 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	8	0	20	78336	0	195840
	DK LONG'L 9"x4"x5/16" FLG PL	13.8	lb/ft	40	ft	21	840	11600	7.5	0	20	87003	0	232008
	FULL DK TRANSV 18"x4"x5/16" FLG PL	23.4	lb/ft	24	ft	2	48	1121.8	7.25	0	20	8132.76	0	22435.2
	PARTIAL DECK TRANSV 18"x4"x5/16" FLG PL	23.4	lb/ft	8	ft	1	8	186.96	7.25	0	24	1355.46	0	4487.04
	DK TRANSV BKT 5/16" bktt	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	6.25	0	24	111.5625	0	428.4
100	TOTAL							60539	4.67	0	20	282810.8	0	1208746

CEN.ERWT
-H36 STEEL DECK
-4 ft Transverse spacing
-Longitudinally framed
-12" deck beam spacing

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
100	STRUCTURE													
111	SHELL PLATING													
	BOTTOM SHELL 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	0	0	20	0	0	195840
	SIDE SHELL 1/4" PL	10.2	lb/ft^2	320	ft^2	2	640	6528	4	0	20	26112	0	130560
	TRANSOM 5/16" PL	12.8	lb/ft^2	192	ft^2	2	384	4896	4	0	20	19584	0	97920
	SIDE SHELL/TRANSOM BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	12	2.64	33.66	4	0	20	134.64	0	673.2
116	LONG'L FRAMING													
	BOTTOM LONG'L 5"x3"x5/16" OA	8.2	lb/ft	40	ft	9	360	2952	0.3	0	20	885.6	0	59040
	SIDE LONG'L 4"x3"x1/4" OA	5.8	lb/ft	40	ft	6	240	1392	4	0	20	5568	0	27840
	TRANSOM BKT 5/16" PL (TOP)	12.8	lb/ft^2	1.3	ft^2	38	49.4	629.85	7	0	20	4408.95	0	12597
	TRANSOM BKT 5/16" PL (BTM)	12.8	lb/ft^2	1.3	ft^2	18	23.4	298.35	1	0	20	298.35	0	5967
117	TRANSVERSE FRAMING													
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	24	ft	7	168	2320.1	0.71	0	20	1647.257	0	46401.6
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	8	ft	1	8	110.48	0.71	0	24	78.4408	0	2651.52
	SIDE TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	14	84	1444.8	4	0	20	5779.2	0	28896
	TRANSOM FRAMING 4"x3"x1/4" OA	5.8	lb/ft	24	ft	6	144	835.2	4	0	20	3340.8	0	16704
	TRANSOM HORIZONTAL BKT 5/16"	12.8	lb/ft^2	0.45	ft^2	24	10.8	137.7	4	0	20	550.8	0	2754
	BTM TRANSV BKT 5/16"	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	1.1	0	24	19.635	0	428.4
121	LONG'L STRUCTURAL BULKHEAD													
	BHD PLATING 1/4" PL	10.2	lb/ft	320	ft	2	640	6528	4	0	20	26112	0	130560
	BHD LONG'L 3"x2"x1/4" OA	4.1	lb/ft	38	ft	6	228	934.8	4	0	20	3739.2	0	18696
	LONG'L END BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	6	1.32	16.83	4	0	20	67.32	0	336.6

CEI..ERWT
-H36 STEEL DECK
-4 ft Transverse spacing
-Longitudinally framed
-12" deck beam spacing

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
	BHD TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256
122	TRANSV STRUCTURAL BULKHEAD													
	PARTIAL BHD 1/4" PL	10.2	lb/ft^2	64	ft^2	2	128	1305.6	4	0	24	5222.4	0	31334.4
	PARTIAL BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	6	39.54	162.11	3.75	0	24	607.9275	0	3890.736
	BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	6	2.7	34.425	0.6	0	24	20.655	0	826.2
	TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	6	6	76.5	6.7	0	24	512.55	0	1836
	HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	24	550.8	0	3304.8
	FULL TRANSV BHD 1/4" PL	10.2	lb/ft^2	192	ft^2	1	192	1958.4	4	0	16	7833.6	0	31334.4
	- BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	9	59.31	243.17	3.75	0	16	911.8913	0	3890.736
	- BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	9	4.05	51.638	0.6	0	16	30.9825	0	826.2
	- TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	9	9	114.75	6.7	0	16	768.825	0	1836
	- HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	16	550.8	0	2203.2
131	MAIN DK													
	MAIN DK PLATING 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	8	0	20	78336	0	195840
	DK LONG'L 6" x 3.5" x 5/16"	9.8	lb/ft	40	ft	21	840	8232	7.5	0	20	61740	0	164640
	FULL DK TRANSV 15"x4"x1/4" FLG PL	16	lb/ft	24	ft	7	168	2688	7.25	0	20	19488	0	53760
	PARTIAL DECK TRANSV 18"x4"x5/16" FLG PL	23.4	lb/ft	8	ft	1	8	186.96	7.25	0	24	1355.46	0	4487.04
	DK TRANSV BKT 5/16" PLT	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	6.25	0	24	111.5625	0	428.4
100	TOTAL							64419	4.32	0	20	278018.8	0	1286559

CE. . ERWT

H36 STEEL DECK (8 ft Transverse spacing)

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
100	STRUCTURE													
111	SHELL PLATING													
	BOTTOM SHELL 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	0	0	20	0	0	195840
	SIDE SHELL 1/4" PL	10.2	lb/ft^2	320	ft^2	2	640	6528	4	0	20	26112	0	130560
	TRANSOM 5/16" PL	12.8	lb/ft^2	192	ft^2	2	384	4896	4	0	20	19584	0	97920
	SIDE SHELL/TRANSOM BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	12	2.64	33.66	4	0	20	134.64	0	673.2
116	LONG'L FRAMING													
	BOTTOM LONG'L 5"x3"x5/16" OA	8.2	lb/ft	40	ft	9	360	2952	0.3	0	20	885.6	0	59040
	SIDE LONG'L 4"x3"x1/4" OA	5.8	lb/ft	40	ft	6	240	1392	4	0	20	5568	0	27840
	TRANSOM BKT 5/16" PL (TOP)	12.8	lb/ft^2	1.3	ft^2	38	49.4	629.85	7	0	20	4408.95	0	12597
	TRANSOM BKT 5/16" PL (BTM)	12.8	lb/ft^2	1.3	ft^2	18	23.4	298.35	1	0	20	298.35	0	5967
117	TRANSVERSE FRAMING													
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	24	ft	2	48	662.88	0.71	0	20	470.6448	0	13257.6
	BOTTOM TRANSV 10"x3"x5/16" FLG PL	13.8	lb/ft	8	ft	1	8	110.48	0.71	0	24	78.4408	0	2651.52
	SIDE TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256
	TRANSOM FRAMING 4"x3"x1/4" OA	5.8	lb/ft	24	ft	6	144	835.2	4	0	20	3340.8	0	16704
	TRANSOM HORIZONTAL BKT 5/16"	12.8	lb/ft^2	0.45	ft^2	24	10.8	137.7	4	0	20	550.8	0	2754
	BTM TRANSV BKT 5/16"	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	1.1	0	24	19.635	0	428.4
121	LONG'L STRUCTURAL BULKHEAD													
	BHD PLATING 1/4" PL	10.2	lb/ft	320	ft	2	640	6528	4	0	20	26112	0	130560
	BHD LONG'L 3"x2"x1/4" OA	4.1	lb/ft	38	ft	6	228	934.8	4	0	20	3739.2	0	18696
	LONG'L END BKT 5/16" PL	12.8	lb/ft^2	0.22	ft^2	6	1.32	16.83	4	0	20	67.32	0	336.6
	BHD TRANSV 8"x4"x7/16" OA	17.2	lb/ft	6	ft	4	24	412.8	4	0	20	1651.2	0	8256

H36 STEEL DECK (8 ft Transverse spacing)

SWBS	ITEM DESCRIPTION	UNIT WT	UNIT	QTY	UNIT	NO. OFF	TOT'L QTY	WT [LB.]	VCG	TCG	LCG	Vmom	Tmom	Lmom
122	TRANSV STRUCTURAL BULKHEAD													
	PARTIAL BHD 1/4" PL	10.2	lb/ft^2	64	ft^2	2	128	1305.6	4	0	24	5222.4	0	31334.4
	PARTIAL BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	6	39.54	162.11	3.75	0	24	607.9275	0	3890.736
	BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	6	2.7	34.425	0.6	0	24	20.655	0	826.2
	TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	6	6	76.5	6.7	0	24	512.55	0	1836
	HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	24	550.8	0	3304.8
	FULL TRANSV BHD 1/4" PL	10.2	lb/ft^2	192	ft^2	1	192	1958.4	4	0	16	7833.6	0	31334.4
	- BHD STIFF'R 3"x2"x1/4" OA	4.1	lb/ft	6.59	ft	9	59.31	243.17	3.75	0	16	911.8913	0	3890.736
	- BOTTOM BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.45	ft^2	9	4.05	51.638	0.6	0	16	30.9825	0	826.2
	- TOP BKT 5/16" (COMBINED)	12.8	lb/ft^2	1	ft^2	9	9	114.75	6.7	0	16	768.825	0	1836
	- HOR BKT 5/16" (COMBINED)	12.8	lb/ft^2	0.9	ft^2	12	10.8	137.7	4	0	16	550.8	0	2203.2
131	MAIN DK													
	MAIN DK PLATING 1/4" PL	10.2	lb/ft^2	960	ft^2	1	960	9792	8	0	20	78336	0	195840
	DK LONG'L 15"x4"x5/16" FLG PL	16	lb/ft	40	ft	9	360	5760	7.5	0	20	43200	0	115200
	FULL DK TRANSV 24"x4"x1/4" FLG PL	25	lb/ft	24	ft	2	48	1200	7.25	0	20	8700	0	24000
	PARTIAL DECK TRANSV 24"x4"x1/4" FLG PL	25	lb/ft	8	ft	1	8	200	7.25	0	24	1450	0	4800
	DK TRANSV BKT 5/16" PLT	12.8	lb/ft^2	0.7	ft^2	2	1.4	17.85	6.25	0	24	111.5625	0	428.4
169	WT HATCH	150	lb	1	ea.	1	1	150	8	10.5	22.5	1200	1575	3375
100	TOTAL							57933	4.22	0.03	20	244680.8	1575	1157263

APPENDIX F

Stability Calculations

STABILITY CONDITION SUMMARY SHEET

Load Condition	Unloaded 40 ft module
Case 0	Intact

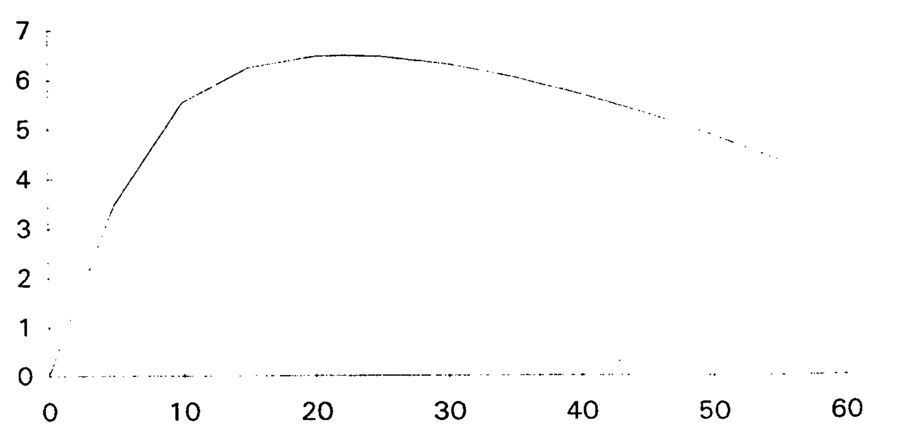
Displacement	30 LT		
Draft	1.09 ft	trim	0 ft
VCG	4.5 ft	heel	0 deg
GM	39.9 ft		

Damage

31	21	11
	22	12
33	23	13

Heel Angle	Righting Arm	Area
0	0	0
5	3.494	8.74
10	5.547	31.3
15	6.243	60.8
20	6.473	92.6
22.26	6.492	107
25	6.465	125
30	6.307	157
35	6.044	188
40	5.702	217
45	5.303	245
50	4.864	270
55	4.372	293

Stability Criteria		
Righting Area 0-40 deg	> 15 ft deg	217 OK



STABILITY CONDITION SUMMARY SHEET

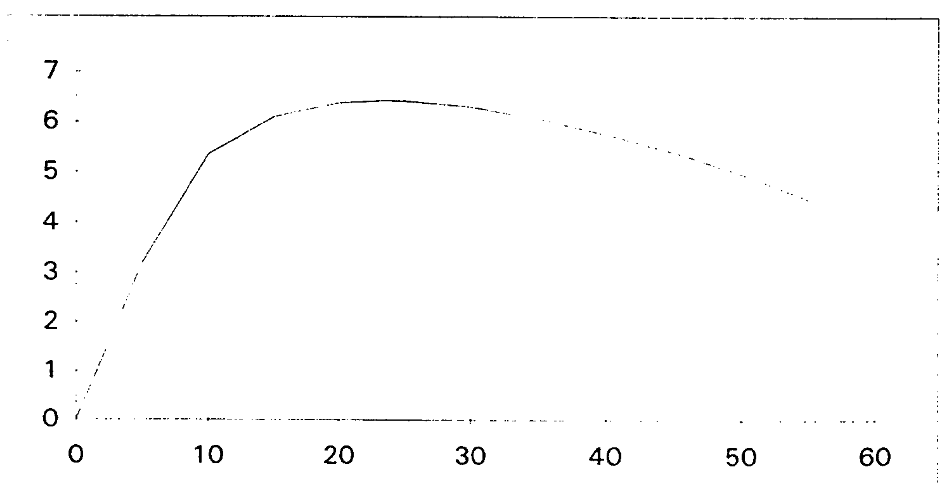
Load Condition	Unloaded 120 foot barge
Case 0	Intact

Displacement	90 LT		
Draft	1.24 ft	trim	0 ft
VCG	4.5 ft	heel	0 deg
GM	35.4 ft		

Damage

91	81	71	61	51	41	31	21	11
92		72		52	42		22	12
93	83	73	63	53	43	33	23	13

Heel Angle	Righting Arm	Area	Stability Criteria		
0	0	0	Righting Area 0-40 deg	> 15 ft deg	214 OK
5	3.18	7.95			
10	5.361	29.3			
15	6.106	58			
20	6.384	89.2			
23.55	6.43	112			
25	6.422	121			
30	6.307	153			
35	6.08	184			
40	5.77	214			
45	5.402	242			
50	4.988	268			
55	4.491	291			



STABILITY CONDITION SUMMARY SHEET

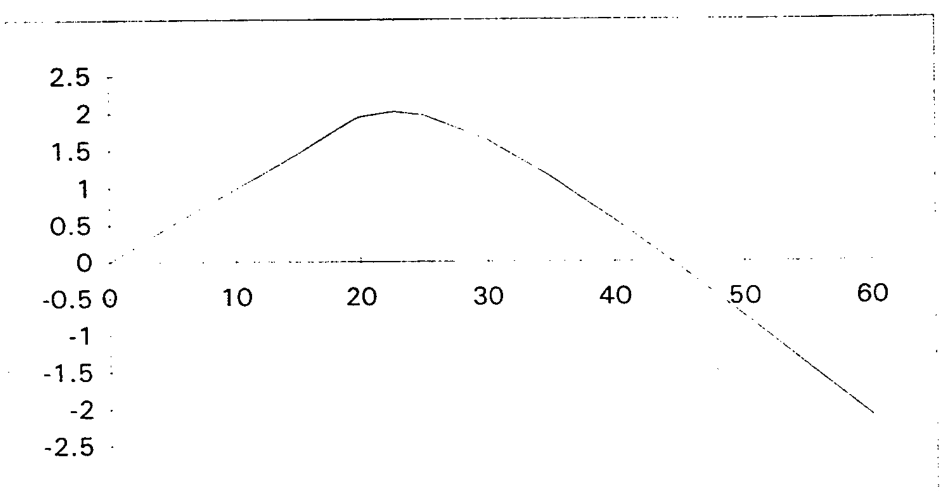
Load Condition	200 LT Cargo
Case 0	Intact
Displacement	290 LT
Draft	3.88 ft
VCG	9.96 ft
GM	4.99 ft

Damage

91	81	71	61	51	41	31	21	11
92		72		52	42		22	12
93	83	73	63	53	43	33	23	13

Heel Angle	Righting Arm	Area
0	0	0
5	0.504	0.94
10	0.982	4.67
15	1.459	10.8
19.37	1.906	18.1
20	1.951	19.3
22.66	2.02	24.6
25	1.966	29.3
30	1.64	38.4
35	1.146	45.4
40	0.56	49.8
44.39	0	51
45	-0.08	
50	-0.749	
55	-1.433	
60	-2.12	

Stability Criteria		
Righting Area 0-40 deg	>15 ft deg	50 OK



STABILITY CONDITION SUMMARY SHEET

Load Condition	200 LT Cargo
Case 1	Damage to Tanks 12 and 13

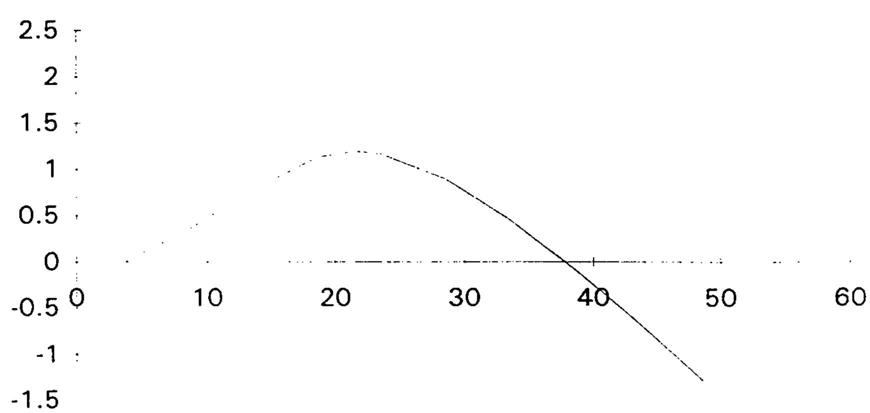
Displacement	290 LT		
Draft	4.2 ft	trim	1.89 ft
VCG	9.96 ft	heel	3.67 deg
GM	4.3 ft		

Damage

91	81	71	61	51	41	31	21	11
92		72		52	42		22	12
93	83	73	63	53	43	33	23	13

Heel Angle	Righting Arm	Area
3.67	0	0
8.67	0.365	0.68
12.04	0.637	2.37
13.67	0.776	3.52
18.67	1.134	8.3
21.63	1.195	11.8
23.67	1.164	14.2
28.67	0.893	19.5
33.67	0.447	22.9
37.88	0	23.8
38.67	-0.088	23.8
43.67	-0.675	21.9
48.67	-1.286	17

Stability Criteria		
Equilibrium heel	<15 deg	3.7 OK
Stability Range	>15 deg	34 OK
Min. Freeboard	> 0 ft	2.1 OK



STABILITY CONDITION SUMMARY SHEET

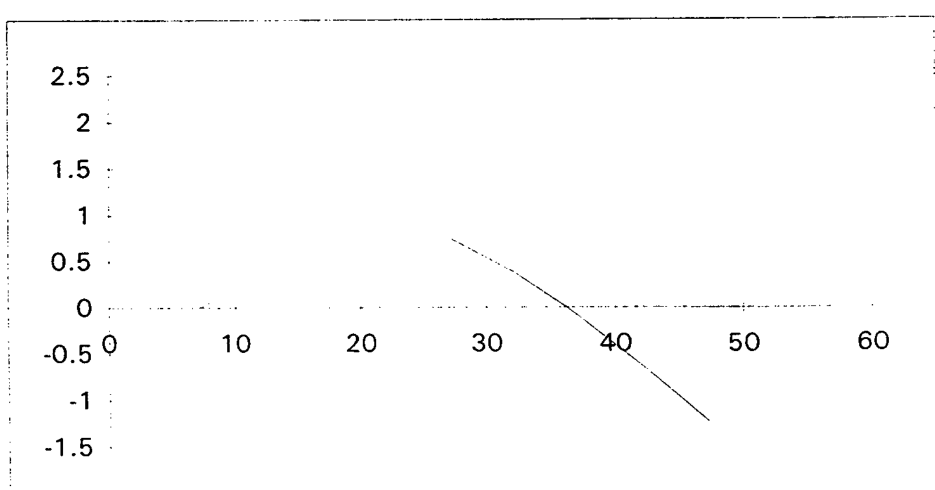
Load Condition	200 LT Cargo		
Case 2	Damage to Tanks 13 and 23		
Displacement	290 LT		
Draft	4.18 ft	trim	1.69 ft
VCG	9.96 ft	heel	7.2 deg
GM	4.1 ft		

Damage

91	81	71	61	51	41	31	21	11
92		72		52	42		22	12
93	83	73	63	53	43	33	23	13

Heel Angle	Righting Arm	Area
7.2	0	0
12.2	0.353	0.65
13.12	0.424	1.01
17.2	0.733	3.36
22.2	0.902	7.51
27.2	0.749	11.8
32.2	0.384	14.7
36.22	0	15.5
37.2	-0.1	15.4
42.2	-0.648	13.6
47.2	-1.229	8.92

Stability Criteria		
Equilibrium heel	<15 deg	7.2 OK
Stability Range	>15 deg	29 OK
Min. Freeboard	> 0 ft	1.4 OK



STABILITY CONDITION SUMMARY SHEET

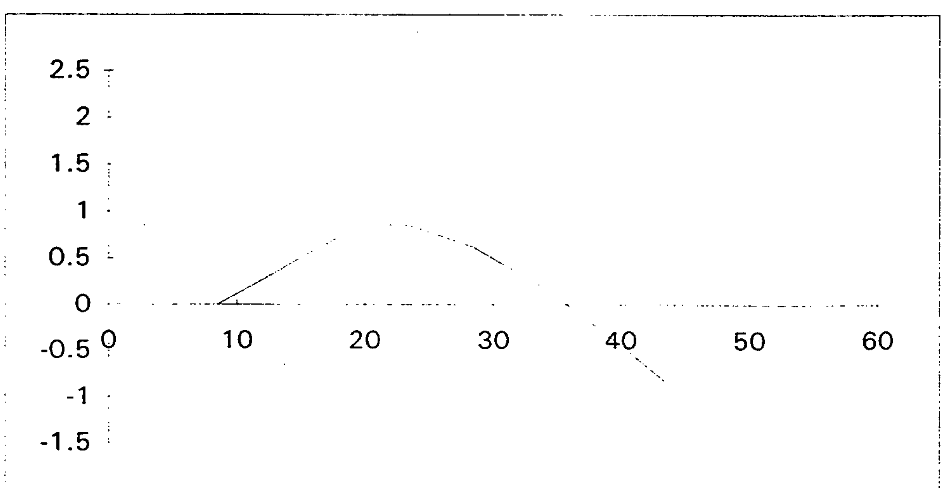
Load Condition	200 LT Cargo		
Case 3	Damage to Tanks 23 and 33		
Displacement	290 LT		
Draft	4.24 ft	trim	1.39 ft
VCG	9.96 ft	heel	8.5 deg
GM	4.3 ft		

Damage

91	81	71	61	51	41	31	21	11
92		72		52	42		22	12
93	83	73	63	53	43	33	23	13

Heel Angle	Righting Arm	Area
8.5	0	0
13.5	0.381	0.71
14.09	0.428	0.95
18.5	0.755	3.56
22.2	0.86	6.58
23.5	0.847	7.69
28.5	0.621	11.4
33.5	0.221	13.5
35.82	0	13.8
38.5	-0.275	13.4
43.5	-0.826	10.7

Stability Criteria		
Equilibrium heel	<15 deg	8.5 OK
Stability Range	>15 deg	27 OK
Min. Freeboard	> 0 ft	1.2 OK



STABILITY CONDITION SUMMARY SHEET

Load Condition	200 LT Cargo
Case 4	Damage to Tanks 33 and 43

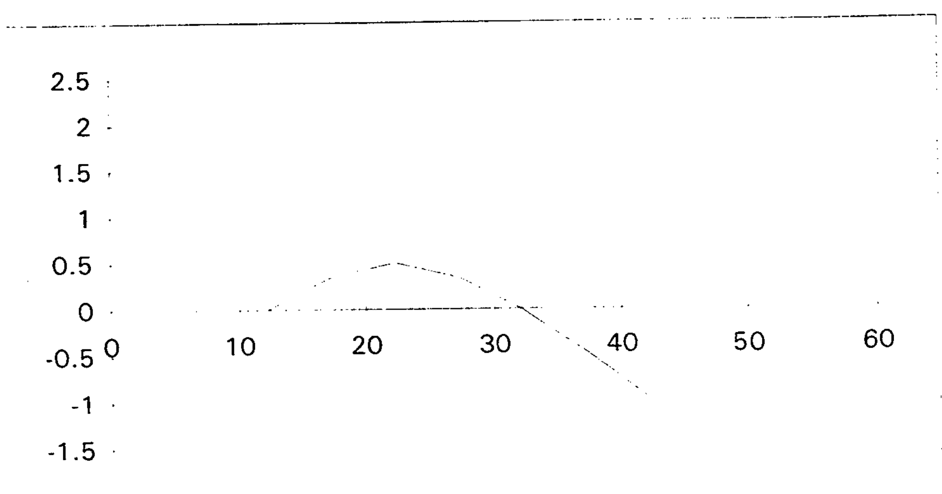
Displacement	290 LT		
Draft	4.41 ft	trim	1.28 ft
VCG	9.96 ft	heel	12.33 deg
GM	4.31 ft		

Damage

91	81	71	61	51	41	31	21	11
92		72		52	42		22	12
93	83	73	63	53	43	33	23	13

Heel Angle	Righting Arm	Area
12.33	0	0
14.91	0.188	0.01
17.33	0.35	0.67
22.33	0.504	2.89
27.33	0.338	5.12
32.12	0	6
32.33	-0.018	6
37.33	-0.475	4.81
42.33	-0.993	1.16

Stability Criteria		
Equilibrium heel	<15 deg	12 OK
Stability Range	>15 deg	20 OK
Min. Freeboard	> 0 ft	0.3 OK



STABILITY CONDITION SUMMARY SHEET

Load Condition	200 LT Cargo
Case 5	Damage to Tanks 43 and 53

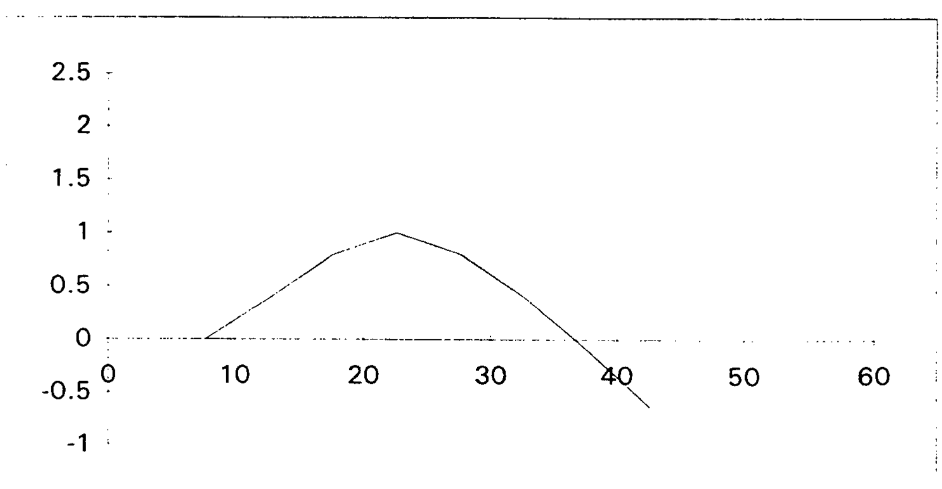
Displacement	290 LT		
Draft	4.21 ft	trim	0.31 ft
VCG	9.96 ft	heel	7.62 deg
GM	4.27 ft		

Damage

91	81	71	61	51	41	31	21	11
92		72		52	42		22	12
93	83	73	63	53	43	33	23	13

Heel Angle	Righting Arm	Area
7.62	0	0
12.62	0.374	0.94
16.51	0.7	3.02
17.62	0.796	3.85
22.62	1	8.34
22.66	1	8.38
27.62	0.804	12.9
32.62	0.409	15.9
36.79	0	16.7
37.62	-0.086	16.7
42.62	-0.636	14.9

Stability Criteria		
Equilibrium heel	<15 deg	7.6 OK
Stability Range	>15 deg	29 OK
Min. Freeboard	> 0 ft	2 OK



Unloaded 40' module

WEIGHT and DISPLACEMENT STATUS
Baseline draft: 1.094. Heel: zero

Part	Weight(LT)	LCG	TCG	VCG
Total Weight-------->	30.00	0.00	0.00	4.50

	SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL	1.025	30.00	0.00	0.00	0.55	-1.09
Righting Arms:			0.00	0.00		

Distances in FEET.

HYDROSTATIC PROPERTIES
No Trim, No Heel, VCG = 4.50

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	Buoyancy Ctr. VCB	Weight/ Inch	LCF	Moment/ Deg trim	GML	GMT
1.094	30.00	0.00	0.55	2.29	0.00	61.75	117.9	39.92

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE

LCG = 0.00 TCG = 0.00 VCG = 4.50

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(LT)	Righting Arms in Trim	Righting Arms in Heel
1.094	0.00	0.00	30.00	0.00	0.000
1.090	0.00	5.00s	30.00	0.00	3.494s
0.913	0.00	10.00s	30.00	0.00	5.547s
0.517	0.00	15.00s	30.00	0.00	6.243s
0.004	0.00	20.00s	30.00	0.00	6.473s
-0.255	0.00	22.26s	30.00	0.00	6.492s
-0.587	0.00	25.00s	30.00	0.00	6.465s
-1.232	0.00	30.00s	30.00	0.00	6.307s
-1.917	0.00	35.00s	29.99	0.00	6.044s
-2.629	0.00	40.00s	30.00	0.00	5.702s
-3.361	0.00	45.00s	30.00	0.00	5.303s
-4.108	0.00	50.00s	30.00	0.00	4.864s
-4.847	0.00	55.00s	30.00	0.00	4.372s
-5.550	0.00	60.00s	30.00	0.00	3.799s
-6.211	0.00	65.00s	30.00	0.00	3.163s
-6.824	0.00	70.00s	30.00	0.00	2.481s
-7.386	0.00	75.00s	30.00	0.00	1.762s
-7.891	0.00	80.00s	30.00	0.00	1.020s
-8.336	0.00	85.00s	30.00	0.00	0.263s
-8.475	0.00	86.72s	30.00	0.00	0.000s
-8.718	0.00	90.00s	30.00	0.00	-0.500s

Distances in FEET.--Specific Gravity = 1.025.-----------

unloaded [illegible] module

ACB 120 feet module subdivision 2

WEIGHT and DISPLACEMENT STATUS
Baseline draft: 1.242. Heel: zero

Part	SpGr	Weight(LT) / Displ(LT)	LCG / LCB	TCG / TCB	VCG / VCB	Ref Ht
Total Weight-------->		90.00	0.00	0.00	4.50	
HULL	1.025	90.00	0.00	0.00	0.63	-1.24
Righting Arms:			0.00	0.00		

Distances in FEET.

HYDROSTATIC PROPERTIES
No Trim, No Heel, VCG = 4.50

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	Buoyancy Ctr. VCB	Weight/ Inch	LCF	Moment/ Deg trim	GML	GMT
1.242	90.00	0.00	0.63	6.13	0.00	1226.33	780.6	35.36

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE

LCG = 0.00 TCG = 0.00 VCG = 4.50

Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	--> Area
1.242	0.00	0.00	90.00	0.00	0.000	0.00
1.233	0.00	5.00s	90.00	0.00	3.180s	5.97
1.075	0.00	10.00s	90.00	0.00	5.361s	27.74
0.708	0.00	15.00s	90.00	0.00	6.106s	57.01
0.212	0.00	20.00s	90.03	0.00	6.384s	88.43
-0.195	0.00	23.55s	90.00	0.00	6.430s	111.24
-0.372	0.00	25.00s	89.97	0.00	6.422s	120.53
-1.015	0.00	30.00s	89.98	0.00	6.307s	152.43
-1.702	0.00	35.00s	89.95	0.00	6.080s	183.44
-2.418	0.00	40.00s	90.00	0.00	5.770s	213.10
-3.161	0.00	45.00s	89.94	0.00	5.402s	241.06
-3.916	0.00	50.00s	90.00	0.00	4.988s	267.05
-4.653	0.00	55.00s	90.00	0.00	4.491s	290.78
-5.354	0.00	60.00s	90.00	0.00	3.915s	311.83
-6.015	0.00	65.00s	90.00	0.00	3.278s	329.84
-6.630	0.00	70.00s	90.00	0.00	2.595s	344.54
-7.195	0.00	75.00s	90.00	0.00	1.876s	355.73
-7.705	0.00	80.00s	90.00	0.00	1.133s	363.27
-8.156	0.00	85.00s	90.00	0.00	0.375s	367.05
-8.355	0.00	87.46s	90.00	0.00	0.000s	367.51
-8.545	0.00	90.00s	90.00	0.00	-0.388s	367.02

Distances in FEET.---Specific Gravity = 1.025.----Area in Ft-Deg.

****
* CASE 0 *
* INTACT STABILITY *
****

WEIGHT and DISPLACEMENT STATUS
Baseline draft: 3.875, Heel: zero

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	0.00	12.42
Total Weight-------->	290.00	0.00	0.00	9.96

	SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL	1.025	290.03	0.00	0.00	1.98	-3.88
Righting Arms:			0.00	0.00		

Distances in FEET.

Baseline draft: 3.875, Heel: zero

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	4.12
(2) DECK CORNER SS	60.00a	12.00s	8.00	4.12
(3) DECK CORNER PB	60.00f	12.00p	8.00	4.12
(4) DECK CORNER SB	60.00f	12.00s	8.00	4.12

HYDROSTATIC PROPERTIES
No Trim, No Heel, VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
3.875	290.03	0.00	1.98	6.53	0.00	57.69	286.4	4.99

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft
Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE

LCG = 0.00 TCG = 0.00 VCG = 9.96

Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	--> Area	Critical Height
3.875	0.00	0.00	290.03	0.00	0.000	0.00	4.12(1)
3.866	0.00	5.00s	290.00	0.00	0.504s	0.94	3.60(2)
3.782	0.00	10.00s	290.00	0.00	0.982s	4.67	2.01(2)
3.690	0.00	15.00s	290.00	0.00	1.459s	10.77	0.93(2)
3.573	0.00	19.37s	290.06	0.00	1.906s	18.11	-0.01(2)
3.549	0.00	20.00s	290.06	0.00	1.951s	19.33	-0.14(2)
3.442	0.00	22.66s	290.00	0.00	2.020s	24.61	-0.68(2)
3.342	0.00	25.00s	290.01	0.00	1.966s	29.27	-1.16(2)
3.110	0.00	30.00s	290.00	0.00	1.640s	38.41	-2.18(2)
2.854	0.00	35.00s	290.00	0.00	1.146s	45.44	-3.18(2)
2.577	0.00	40.00s	290.00	0.00	0.560s	49.75	-4.16(2)
2.318	0.00	44.39s	290.05	0.00	0.000s	50.99	-5.00(2)
2.280	0.00	45.00s	290.02	0.00	-0.080s	50.97	-5.11(2)
1.965	0.00	50.00s	290.00	0.00	-0.749s	48.91	-6.02(2)
1.636	0.00	55.00s	290.00	0.00	-1.433s	43.46	-6.88(2)
1.294	0.00	60.00s	290.00	0.00	-2.120s	34.58	-7.69(2)
0.942	0.00	65.00s	290.00	0.00	-2.800s	22.27	-8.44(2)
0.584	0.00	70.00s	290.00	0.00	-3.466s	6.60	-9.12(2)
0.220	0.00	75.00s	290.00	0.00	-4.110s	-12.35	-9.74(2)
-0.145	0.00	80.00s	290.00	0.00	-4.725s	-34.45	-10.28(2)
-0.508	0.00	85.00s	290.00	0.00	-5.306s	-59.54	-10.75(2)
-0.867	0.00	90.00s	290.04	0.00	-5.848s	-87.44	-11.13(2)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Points	Long.	Trans.	Vert.
(1) DECK CORNER PS	60.00a	12.00p	8.00
(2) DECK CORNER SS	60.00a	12.00s	8.00

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**********************************************
*            CASE 1                          *
*   DAMAGE TO TANK 12 AND 13                 *
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WEIGHT and DISPLACEMENT STATUS

Baseline draft: 4.203 @ Origin. Trim: Fwd 1.89/120.00. Heel: Stbd 3.67 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	0.00	12.42
Total Weight-------->	290.00	0.00	0.00	9.96

		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	317.55	4.45f	0.84s	2.22	-4.19
TANK12.C	Flooded	1.025	-12.89	49.96f	0.18s	2.81	-4.19
TANK13.S	Flooded	1.025	-14.66	50.17f	8.22s	3.12	-4.19
Total Displacement-->		1.025	290.00	0.11f	0.50s	2.15	
Righting Arms:				0.01a	0.00s		

Distances in FEET.

Baseline draft: 4.203 @ Origin. Trim: Fwd 1.89/120.00. Heel: Stbd 3.67 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	5.50
(2) DECK CORNER SS	60.00a	12.00s	8.00	3.97
(3) DECK CORNER PB	60.00f	12.00p	8.00	3.61
(4) DECK CORNER SB	60.00f	12.00s	8.00	2.08

HYDROSTATIC PROPERTIES WITH DAMAGE

Trim: Fwd 1.89/120.00. Heel: Stbd 3.67 deg., VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
4.148	290.00	0.11f	2.15	6.02	3.50a	45.79	227.4	4.30

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE with DAMAGE

LCG = 0.00 TCG = 0.00 VCG = 9.96

Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	--> Area	Critical Height
4.194	0.90f	3.67s	290.00	0.01a	0.000s	0.00	2.08(4)
4.193	1.04f	8.67s	290.00	0.00	0.365s	0.68	1.45(4)
4.159	1.13f	12.04s	290.00	0.00	0.637s	2.37	-0.02(4)
4.139	1.17f	13.67s	290.00	0.00	0.776s	3.52	-0.43(4)
4.078	1.35f	18.67s	290.00	0.00	1.134s	8.30	-1.75(4)
4.044	1.55f	21.63s	290.05	0.00	1.195s	11.78	-2.65(4)
4.018	1.71f	23.67s	290.00	0.00	1.164s	14.18	-3.30(4)
3.942	2.14f	28.67s	289.95	0.00	0.893s	19.45	-4.93(4)
3.843	2.58f	33.67s	290.05	0.00	0.447s	22.87	-6.54(4)
3.734	2.93f	37.88s	290.05	0.01a	0.000s	23.84	-7.85(4)
3.711	3.00f	38.67s	290.00	0.00	-0.088s	23.80	-8.10(4)
3.552	3.39f	43.67s	290.05	0.00	-0.675s	21.92	-9.60(4)
3.363	3.75f	48.67s	290.06	0.00	-1.286s	17.03	-11.01(4)
3.147	4.08f	53.67s	290.04	0.00	-1.905s	9.06	-12.33(4)
2.902	4.37f	58.67s	290.00	0.00	-2.522s	-2.01	-13.54(4)
2.636	4.60f	63.67s	290.05	0.00	-3.128s	-16.14	-14.63(4)
2.343	4.79f	68.67s	289.98	0.00	-3.714s	-33.26	-15.59(4)
2.034	4.93f	73.67s	290.00	0.00	-4.277s	-53.24	-16.42(4)
1.708	5.02f	78.67s	290.00	0.00	-4.811s	-75.98	-17.12(4)
1.369	5.07f	83.67s	290.00	0.00	-5.310s	-101.29	-17.68(4)
1.022	5.07f	88.67s	290.05	0.01a	-5.771s	-129.01	-18.09(4)
0.662	5.04f	93.67s	289.98	0.00	-6.188s	-158.92	-18.37(4)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(4) DECK CORNER SB	60.00f	12.00s	8.00

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***********************************************
*              CASE 2                         *
*   DAMAGE TO TANK 23 AND 13                  *
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WEIGHT and DISPLACEMENT STATUS

Baseline draft: 4.181 @ Origin. Trim: Fwd 1.69/120.00. Heel: Stbd 7.20 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	0.00	12.42
Total Weight-------->	290.00	0.00	0.00	9.96

		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	316.36	3.95f	1.58s	2.28	-4.15
TANK13.S	Flooded	1.025	-15.99	50.29f	8.24s	3.35	-4.15
TANK23.S	Flooded	1.025	-10.37	40.01f	8.12s	2.89	-4.15
Total Displacement-->		1.025	290.00	0.11f	0.98s	2.20	
Righting Arms:				0.00	-0.00s		

Distances in FEET.

Baseline draft: 4.181 @ Origin. Trim: Fwd 1.69/120.00. Heel: Stbd 7.20 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	6.13
(2) DECK CORNER SS	60.00a	12.00s	8.00	3.13
(3) DECK CORNER PB	60.00f	12.00p	8.00	4.45
(4) DECK CORNER SB	60.00f	12.00s	8.00	1.44

HYDROSTATIC PROPERTIES WITH DAMAGE

Trim: Fwd 1.69/120.00. Heel: Stbd 7.20 deg.. VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
4.148	290.00	0.11f	2.20	6.17	2.29a	50.31	249.8	4.10

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE with DAMAGE

LCG = 0.00 TCG = 0.00 VCG = 9.96

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(LT)	Righting Arms in Trim	Righting Arms in Heel	--> Area	Critical Height
4.147	0.80f	7.20s	290.00	0.00	-0.001s	0.00	1.44(4)
4.142	0.97f	12.20s	290.00	0.00	0.353s	0.65	0.79(4)
4.119	1.00f	13.12s	290.00	0.00	0.424s	1.01	-0.10(4)
4.074	1.12f	17.20s	290.00	0.00	0.733s	3.36	-1.15(4)
4.004	1.38f	22.20s	290.00	0.00	0.902s	7.51	-2.58(4)
3.904	1.69f	27.20s	290.00	0.00	0.749s	11.77	-4.05(4)
3.771	1.99f	32.20s	290.01	0.00	0.384s	14.68	-5.48(4)
3.643	2.21f	36.22s	290.00	0.01a	0.001s	15.49	-6.60(4)
3.610	2.27f	37.20s	290.03	0.00	-0.100s	15.44	-6.87(4)
3.420	2.53f	42.20s	289.99	0.00	-0.648s	13.60	-8.20(4)
3.204	2.78f	47.20s	289.99	0.00	-1.229s	8.92	-9.48(4)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(4) DECK CORNER SB	60.00f	12.00s	8.00

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***********************************************
*             CASE 3                          *
*   DAMAGE TO TANK 23 AND 33                  *
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WEIGHT and DISPLACEMENT STATUS

Baseline draft: 4.243 @ Origin. Trim: Fwd 1.39/120.00. Heel: Stbd 8.50 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	0.00	12.42
Total Weight-------->	290.00	0.00	0.00	9.96

		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	321.43	3.22f	1.83s	2.34	-4.20
TANK23.S	Flooded	1.025	-10.64	40.01f	8.13s	2.96	-4.20
TANK33.S	Flooded	1.025	-20.77	28.04f	8.14s	2.89	-4.20
Total Displacement-->		1.025	290.01	0.09f	1.15s	2.27	
Righting Arms:				0.00	0.00s		

Distances in FEET.

Baseline draft: 4.243 @ Origin. Trim: Fwd 1.39/120.00. Heel: Stbd 8.50 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	6.19
(2) DECK CORNER SS	60.00a	12.00s	8.00	2.64
(3) DECK CORNER PB	60.00f	12.00p	8.00	4.79
(4) DECK CORNER SB	60.00f	12.00s	8.00	1.24

HYDROSTATIC PROPERTIES WITH DAMAGE

Trim: Fwd 1.39/120.00. Heel: Stbd 8.50 deg.. VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
4.227	290.01	0.09f	2.27	6.19	1.38a	55.50	275.6	4.30

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE with DAMAGE

LCG = 0.00 TCG = 0.00 VCG = 9.96

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(LT)	Righting Arms in Trim	Righting Arms in Heel	--> Area	Critical Height
4.196	0.66f	8.50s	290.01	0.00	0.000s	0.00	1.24(4)
4.183	0.76f	13.50s	290.00	0.00	0.381s	0.71	0.63(4)
4.154	0.77f	14.09s	290.00	0.00	0.428s	0.95	-0.13(4)
4.106	0.88f	18.50s	290.00	0.00	0.755s	3.56	-1.25(4)
4.067	1.06f	22.20s	290.03	0.01f	0.860s	6.58	-2.30(4)
4.052	1.13f	23.50s	290.05	0.00	0.847s	7.69	-2.68(4)
3.969	1.38f	28.50s	289.97	0.00	0.621s	11.36	-4.11(4)
3.847	1.62f	33.50s	290.01	0.00	0.221s	13.54	-5.49(4)
3.779	1.71f	35.82s	290.00	0.01a	0.001s	13.80	-6.11(4)
3.693	1.83f	38.50s	290.00	0.00	-0.275s	13.44	-6.82(4)
3.510	2.04f	43.50s	290.00	0.00	-0.826s	10.71	-8.10(4)
3.301	2.23f	48.50s	290.00	0.00	-1.406s	5.14	-9.32(4)
3.067	2.40f	53.50s	290.00	0.00	-1.997s	-3.36	-10.46(4)
2.809	2.55f	58.50s	290.00	0.00	-2.587s	-14.82	-11.52(4)
2.530	2.68f	63.50s	290.00	0.00	-3.168s	-29.21	-12.50(4)
2.232	2.78f	68.50s	290.00	0.00	-3.732s	-46.47	-13.37(4)
1.918	2.86f	73.50s	290.00	0.00	-4.273s	-66.49	-14.14(4)
1.588	2.92f	78.50s	290.00	0.00	-4.784s	-89.15	-14.79(4)
1.247	2.95f	83.50s	290.00	0.00	-5.262s	-114.28	-15.34(4)
0.898	2.95f	88.50s	290.06	0.01a	-5.701s	-141.70	-15.75(4)
0.538	2.93f	93.50s	289.99	0.00	-6.096s	-171.21	-16.06(4)
0.177	2.89f	98.50s	290.00	0.00	-6.445s	-202.59	-16.23(4)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(4) DECK CORNER SB	60.00f	12.00s	8.00

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*              CASE 4                       *
*   DAMAGE TO TANK 33 AND 43                *
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WEIGHT and DISPLACEMENT STATUS

Baseline draft: 4.415 @ Origin. Trim: Fwd 1.28/120.00. Heel: Stbd 12.33 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	0.00	12.42
Total Weight-------->	290.00	0.00	0.00	9.96

		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	335.98	2.83f	2.53s	2.57	-4.31
TANK33.S	Flooded	1.025	-23.30	28.04f	8.18s	3.25	-4.31
TANK43.S	Flooded	1.025	-22.67	12.04f	8.19s	3.17	-4.31
Total Displacement-->		1.025	290.01	0.08f	1.64s	2.47	

Righting Arms: 0.00 0.00s

Distances in FEET.

Baseline draft: 4.415 @ Origin. Trim: Fwd 1.28/120.00. Heel: Stbd 12.33 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	6.70
(2) DECK CORNER SS	60.00a	12.00s	8.00	1.58
(3) DECK CORNER PB	60.00f	12.00p	8.00	5.43
(4) DECK CORNER SB	60.00f	12.00s	8.00	0.30

HYDROSTATIC PROPERTIES WITH DAMAGE

Trim: Fwd 1.28/120.00. Heel: Stbd 12.33 deg., VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
4.401	290.01	0.08f	2.47	6.11	1.23a	57.88	287.4	4.31

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE with DAMAGE

LCG = 0.00 TCG = 0.00 VCG = 9.96

Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	--> Area	Critical Height
4.313	0.61f	12.33s	290.01	0.00	0.001s	0.00	0.30(4)
4.293	0.65f	14.91s	289.94	0.01f	0.188s	0.01	-0.33(4)
4.277	0.70f	17.33s	290.01	0.00	0.350s	0.67	-0.95(4)
4.265	0.89f	22.33s	290.00	0.00	0.504s	2.89	-2.35(4)
4.242	1.10f	27.33s	289.98	0.00	0.338s	5.12	-3.80(4)
4.179	1.29f	32.12s	290.03	0.00	0.000s	6.00	-5.14(4)
4.175	1.30f	32.33s	290.00	0.00	-0.018s	6.00	-5.19(4)
4.067	1.48f	37.33s	290.01	0.00	-0.475s	4.81	-6.54(4)
3.928	1.66f	42.33s	290.00	0.00	-0.993s	1.16	-7.83(4)
3.760	1.82f	47.33s	290.00	0.00	-1.542s	-5.16	-9.06(4)
3.562	1.96f	52.33s	290.00	0.00	-2.104s	-14.27	-10.22(4)
3.338	2.09f	57.33s	290.00	0.00	-2.666s	-26.19	-11.30(4)
3.088	2.20f	62.33s	290.00	0.00	-3.219s	-40.91	-12.30(4)
2.815	2.29f	67.33s	290.00	0.00	-3.755s	-58.35	-13.20(4)
2.520	2.36f	72.33s	290.00	0.00	-4.269s	-78.42	-13.99(4)
2.206	2.41f	77.33s	290.00	0.00	-4.753s	-100.99	-14.68(4)
1.876	2.44f	82.33s	290.00	0.00	-5.204s	-125.89	-15.25(4)
1.531	2.45f	87.33s	290.00	0.00	-5.617s	-152.96	-15.70(4)
1.175	2.44f	92.33s	290.00	0.00	-5.988s	-181.99	-16.03(4)
0.810	2.41f	97.33s	290.00	0.00	-6.313s	-212.76	-16.24(4)
0.438	2.35f	102.33s	290.00	0.00	-6.588s	-245.04	-16.32(4)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(4) DECK CORNER SB	60.00f	12.00s	8.00

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***********************************************
*              CASE 5                         *
*   DAMAGE TO TANK 43 AND 53                  *
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WEIGHT and DISPLACEMENT STATUS

Baseline draft: 4.214 @ Origin. Trim: Fwd 0.31/120.00. Heel: Stbd 7.62 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	0.00	12.42
Total Weight-------->	290.00	0.00	0.00	9.96

		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	318.66	0.74f	1.67s	2.28	-4.18
TANK43.S	Flooded	1.025	-19.14	12.01f	8.13s	2.67	-4.18
TANK53.S	Flooded	1.025	-9.52	0.00	8.13s	2.65	-4.18
Total Displacement-->		1.025	290.00	0.02f	1.03s	2.24	
Righting Arms:				0.00	0.00s		

Distances in FEET.

Baseline draft: 4.214 @ Origin. Trim: Fwd 0.31/120.00. Heel: Stbd 7.62 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	5.50
(2) DECK CORNER SS	60.00a	12.00s	8.00	2.32
(3) DECK CORNER PB	60.00f	12.00p	8.00	5.19
(4) DECK CORNER SB	60.00f	12.00s	8.00	2.01

HYDROSTATIC PROPERTIES WITH DAMAGE

Trim: Fwd 0.31/120.00. Heel: Stbd 7.62 deg.. VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
4.213	290.00	0.02f	2.24	6.17	0.38a	59.04	293.2	4.27

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE with DAMAGE

LCG = 0.00 TCG = 0.00 VCG = 9.96

Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	--> Area	Critical Height
4.177	0.15f	7.62s	290.00	0.00	0.001s	0.00	2.01(4)
4.166	0.18f	12.62s	290.00	0.00	0.374s	0.70	1.43(4)
4.097	0.19f	16.51s	290.00	0.01f	0.700s	2.78	-0.04(4)
4.080	0.20f	17.62s	290.01	0.00	0.796s	3.61	-0.29(4)
4.038	0.26f	22.62s	290.04	0.00	1.000s	8.15	-1.54(4)
4.037	0.26f	22.66s	290.01	0.00	1.000s	8.20	-1.55(4)
3.971	0.33f	27.62s	290.02	0.00	0.804s	12.83	-2.79(4)
3.866	0.39f	32.62s	290.01	0.00	0.409s	15.94	-4.01(4)
3.750	0.44f	36.79s	290.00	0.00	0.000s	16.82	-4.99(4)
3.724	0.45f	37.62s	290.02	0.00	-0.086s	16.78	-5.18(4)
3.547	0.50f	42.62s	290.00	0.00	-0.636s	15.00	-6.31(4)
3.342	0.55f	47.62s	290.00	0.00	-1.219s	10.38	-7.39(4)
3.113	0.59f	52.62s	290.00	0.00	-1.818s	2.79	-8.41(4)
2.859	0.63f	57.62s	290.00	0.00	-2.418s	-7.80	-9.37(4)
2.584	0.67f	62.62s	290.00	0.00	-3.012s	-21.37	-10.26(4)
2.289	0.69f	67.62s	290.00	0.00	-3.590s	-37.88	-11.06(4)
1.977	0.71f	72.62s	290.00	0.00	-4.146s	-57.23	-11.79(4)
1.650	0.73f	77.62s	290.00	0.00	-4.675s	-79.30	-12.42(4)
1.310	0.74f	82.62s	290.00	0.00	-5.170s	-103.93	-12.95(4)
0.960	0.74f	87.62s	290.00	0.00	-5.628s	-130.94	-13.39(4)
0.603	0.74f	92.62s	290.00	0.00	-6.042s	-160.13	-13.73(4)
0.241	0.73f	97.62s	290.00	0.00	-6.411s	-191.28	-13.95(4)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(4) DECK CORNER SB	60.00f	12.00s	8.00

offcenter load analysis


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***********************************************
*  CASE 0                                     *
*  INTACT STABILITY                           *
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WEIGHT and DISPLACEMENT STATUS
Baseline draft: 3.857, Heel: Stbd 6.90 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	1.00s	12.42
Total Weight-------->	290.00	0.00	0.69s	9.96

	SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL	1.025	290.00	0.00	1.64s	2.08	-3.83
Righting Arms:			0.00	0.00s		

Distances in FEET.

Baseline draft: 3.857, Heel: Stbd 6.90 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	5.55
(2) DECK CORNER SS	60.00a	12.00s	8.00	2.67
(3) DECK CORNER PB	60.00f	12.00p	8.00	5.55
(4) DECK CORNER SB	60.00f	12.00s	8.00	2.67

HYDROSTATIC PROPERTIES
No Trim, Heel: Stbd 6.90 deg., VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
3.857	290.00	0.00	2.08	6.57	0.00	58.07	288.4	5.20

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE

LCG = 0.00 TCG = 0.69s VCG = 9.96

Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	--> Area	Critical Height
3.829	0.00	6.90s	290.00	0.00	0.000s	0.00	2.67(2)
3.793	0.00	11.90s	290.01	0.00	0.481s	0.90	2.14(2)
3.646	0.00	16.90s	290.00	0.00	1.000s	4.59	0.52(2)
3.572	0.00	19.39s	289.98	0.00	1.258s	7.40	-0.01(2)
3.474	0.00	21.90s	290.05	0.00	1.376s	10.72	-0.53(2)
3.436	0.00	22.80s	290.00	0.00	1.383s	11.97	-0.71(2)
3.257	0.00	26.90s	290.00	0.00	1.255s	17.46	-1.55(2)
3.015	0.00	31.90s	290.00	0.00	0.882s	22.90	-2.56(2)
2.751	0.00	36.90s	290.00	0.00	0.381s	26.11	-3.56(2)
2.561	0.00	40.27s	290.00	0.00	0.000s	26.76	-4.21(2)
2.466	0.00	41.90s	290.00	0.00	-0.191s	26.61	-4.52(2)
2.162	0.00	46.90s	290.00	0.00	-0.802s	24.14	-5.46(2)
1.842	0.00	51.90s	290.00	0.00	-1.434s	18.56	-6.35(2)
1.507	0.00	56.90s	290.00	0.00	-2.071s	9.80	-7.19(2)
1.162	0.00	61.90s	290.00	0.00	-2.705s	-2.14	-7.98(2)
0.807	0.00	66.90s	290.00	0.00	-3.326s	-17.22	-8.71(2)
0.446	0.00	71.90s	290.00	0.00	-3.927s	-35.36	-9.37(2)
0.082	0.00	76.90s	290.00	0.00	-4.503s	-56.45	-9.96(2)
-0.283	0.00	81.90s	290.00	0.00	-5.047s	-80.33	-10.47(2)
-0.646	0.00	86.90s	290.00	0.00	-5.554s	-106.85	-10.90(2)
-1.003	0.00	91.90s	290.01	0.00	-6.019s	-135.81	-11.26(2)
-1.354	0.00	96.90s	290.00	0.00	-6.438s	-166.97	-11.52(2)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(2) DECK CORNER SS	60.00a	12.00s	8.00

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***********************************************
*              CASE 1                         *
*   DAMAGE TO TANK 12 AND 13                  *
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WEIGHT and DISPLACEMENT STATUS

Baseline draft: 4.255 @ Origin. Trim: Fwd 2.39/120.00. Heel: Stbd 12.48 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	1.00s	12.42
Total Weight-------->	290.00	0.00	0.69s	9.96

		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	324.09	5.43f	2.64s	2.54	-4.15
TANK12.C	Flooded	1.025	-13.99	50.17f	0.40s	3.05	-4.15
TANK13.S	Flooded	1.025	-20.11	50.64f	8.24s	4.02	-4.15
Total Displacement-->		1.025	290.00	0.14f	2.36s	2.42	
Righting Arms:				0.01a	0.00s		

Distances in FEET.

Baseline draft: 4.255 @ Origin. Trim: Fwd 2.39/120.00. Heel: Stbd 12.48 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	7.44
(2) DECK CORNER SS	60.00a	12.00s	8.00	2.26
(3) DECK CORNER PB	60.00f	12.00p	8.00	5.06
(4) DECK CORNER SB	60.00f	12.00s	8.00	-0.13

HYDROSTATIC PROPERTIES WITH DAMAGE

Trim: Fwd 2.39/120.00. Heel: Stbd 12.48 deg.. VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
4.183	290.00	0.14f	2.42	6.13	3.55a	46.33	230.1	5.15

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE with DAMAGE

LCG = 0.00 TCG = 0.69s VCG = 9.96

Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	--> Area	Critical Height
4.154	1.14f	12.48s	290.00	0.00	0.001s	0.00	-0.13(4)
4.123	1.29f	17.48s	290.00	0.00	0.414s	0.80	-0.76(4)
4.033	1.61f	22.48s	290.01	0.00	0.552s	3.33	-2.92(4)
3.962	2.04f	27.48s	289.97	0.00	0.366s	5.77	-4.53(4)
3.873	2.45f	32.30s	290.04	0.01a	0.000s	6.72	-6.09(4)
3.868	2.47f	32.48s	290.00	0.00	-0.016s	6.72	-6.15(4)
3.745	2.89f	37.48s	290.05	0.00	-0.501s	5.47	-7.72(4)
3.591	3.29f	42.48s	290.00	0.00	-1.038s	1.65	-9.23(4)
3.409	3.65f	47.48s	290.00	0.00	-1.601s	-4.94	-10.66(4)
3.199	3.99f	52.48s	290.00	0.00	-2.174s	-14.37	-12.00(4)
2.962	4.28f	57.48s	290.00	0.00	-2.743s	-26.67	-13.24(4)
2.702	4.52f	62.48s	290.05	0.00	-3.300s	-41.78	-14.36(4)
2.414	4.72f	67.48s	289.97	0.00	-3.838s	-59.63	-15.34(4)
2.109	4.87f	72.48s	289.99	0.00	-4.351s	-80.12	-16.20(4)
1.787	4.97f	77.48s	290.00	0.00	-4.835s	-103.09	-16.93(4)
1.451	5.03f	82.48s	290.00	0.00	-5.284s	-128.40	-17.52(4)
1.104	5.04f	87.48s	290.00	0.00	-5.695s	-155.87	-17.97(4)
0.748	5.02f	92.48s	290.00	0.00	-6.064s	-185.28	-18.28(4)
0.387	4.95f	97.48s	290.00	0.00	-6.387s	-216.43	-18.45(4)
0.022	4.84f	102.48s	289.98	0.00	-6.662s	-249.07	-18.48(4)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(4) DECK CORNER SB	60.00f	12.00s	8.00

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*********************************************
*              CASE 2                       *
*   DAMAGE TO TANK 23 AND 13                *
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WEIGHT and DISPLACEMENT STATUS

Baseline draft: 4.256 @ Origin. Trim: Fwd 2.27/120.00. Heel: Stbd 16.20 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	1.00s	12.42
Total Weight-------->	290.00	0.00	0.69s	9.96

		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	324.68	5.11f	3.40s	2.74	-4.09
TANK13.S	Flooded	1.025	-21.52	50.71f	8.21s	4.23	-4.09
TANK23.S	Flooded	1.025	-13.16	40.01f	8.18s	3.68	-4.09
Total Displacement-->		1.025	290.00	0.14f	2.83s	2.59	
Righting Arms:				0.00	0.00s		

Distances in FEET.

Baseline draft: 4.256 @ Origin. Trim: Fwd 2.27/120.00. Heel: Stbd 16.20 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	8.08
(2) DECK CORNER SS	60.00a	12.00s	8.00	1.38
(3) DECK CORNER PB	60.00f	12.00p	8.00	5.81
(4) DECK CORNER SB	60.00f	12.00s	8.00	-0.89

HYDROSTATIC PROPERTIES WITH DAMAGE

Trim: Fwd 2.27/120.00. Heel: Stbd 16.20 deg.. VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
4.205	290.00	0.14f	2.59	6.28	2.61a	50.51	250.8	4.94

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE with DAMAGE

LCG = 0.00 TCG = 0.69s VCG = 9.96

Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	--> Area	Critical Height
4.086	1.08f	16.20s	290.00	0.00	0.000s	0.00	-0.89(4)
4.019	1.32f	21.20s	290.00	0.00	0.254s	0.54	-2.28(4)
3.999	1.40f	22.49s	290.00	0.00	0.264s	0.88	-2.66(4)
3.927	1.63f	26.20s	290.00	0.00	0.182s	1.76	-3.75(4)
3.847	1.83f	29.51s	290.03	0.00	0.000s	2.06	-4.71(4)
3.800	1.93f	31.20s	290.00	0.00	-0.120s	1.96	-5.19(4)
3.644	2.21f	36.20s	290.01	0.00	-0.552s	0.32	-6.59(4)
3.460	2.48f	41.20s	290.01	0.00	-1.052s	-3.66	-7.93(4)
3.250	2.72f	46.20s	290.01	0.00	-1.587s	-10.25	-9.22(4)
3.015	2.95f	51.20s	290.01	0.00	-2.137s	-19.55	-10.44(4)
2.757	3.15f	56.20s	290.00	0.00	-2.688s	-31.61	-11.57(4)

Distances in FEET.-------Specific Gravity = 1.025.-----------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(4) DECK CORNER SB	60.00f	12.00s	8.00

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*               CASE 3                       *
*   DAMAGE TO TANK 23 AND 33                 *
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WEIGHT and DISPLACEMENT STATUS

Baseline draft: 4.311 @ Origin. Trim: Fwd 1.75/120.00. Heel: Stbd 17.05 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	1.00s	12.42
Total Weight-------->	290.00	0.00	0.69s	9.96

		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	328.92	3.89f	3.55s	2.80	-4.12
TANK23.S	Flooded	1.025	-13.15	40.01f	8.19s	3.68	-4.12
TANK33.S	Flooded	1.025	-25.77	28.04f	8.21s	3.61	-4.12
Total Displacement-->		1.025	290.00	0.11f	2.92s	2.68	
	Righting Arms:			0.01a	-0.00s		

Distances in FEET.

Baseline draft: 4.311 @ Origin. Trim: Fwd 1.75/120.00. Heel: Stbd 17.05 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	7.92
(2) DECK CORNER SS	60.00a	12.00s	8.00	0.88
(3) DECK CORNER PB	60.00f	12.00p	8.00	6.17
(4) DECK CORNER SB	60.00f	12.00s	8.00	-0.87

HYDROSTATIC PROPERTIES WITH DAMAGE

Trim: Fwd 1.75/120.00. Heel: Stbd 17.05 deg., VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
4.274	290.00	0.11f	2.68	6.24	2.48a	54.03	268.3	4.80

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE with DAMAGE

LCG = 0.00 TCG = 0.69s VCG = 9.96

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(LT)	Righting Arms in Trim	Righting Arms in Heel	--> Area	Critical Height
4.121	0.84f	17.05s	290.00	0.01a	-0.001s	0.00	-0.87(4)
4.068	1.05f	22.05s	290.01	0.00	0.222s	0.49	-2.26(4)
4.063	1.07f	22.49s	290.00	0.00	0.223s	0.59	-2.38(4)
3.997	1.31f	27.05s	289.97	0.00	0.096s	1.43	-3.70(4)
3.965	1.39f	28.75s	290.03	0.00	0.000s	1.51	-4.18(4)
3.886	1.55f	32.05s	290.00	0.00	-0.234s	1.12	-5.09(4)
3.740	1.77f	37.05s	290.00	0.00	-0.674s	-1.10	-6.44(4)
3.566	1.97f	42.05s	290.00	0.00	-1.174s	-5.70	-7.73(4)
3.364	2.16f	47.05s	290.00	0.00	-1.705s	-12.88	-8.96(4)
3.137	2.34f	52.05s	290.00	0.00	-2.248s	-22.76	-10.13(4)
2.886	2.49f	57.05s	290.00	0.00	-2.791s	-35.36	-11.21(4)
2.613	2.63f	62.05s	290.00	0.00	-3.323s	-50.65	-12.21(4)
2.321	2.74f	67.05s	290.00	0.00	-3.839s	-68.56	-13.11(4)
2.010	2.82f	72.05s	290.00	0.00	-4.331s	-88.99	-13.91(4)
1.685	2.88f	77.05s	290.00	0.00	-4.793s	-111.82	-14.59(4)
1.347	2.92f	82.05s	290.00	0.00	-5.222s	-136.87	-15.17(4)
0.998	2.93f	87.05s	290.00	0.00	-5.613s	-163.97	-15.62(4)
0.643	2.92f	92.05s	290.01	0.00	-5.962s	-192.93	-15.96(4)
0.282	2.88f	97.05s	290.00	0.00	-6.265s	-223.52	-16.17(4)
-0.081	2.82f	102.05s	290.00	0.00	-6.520s	-255.50	-16.26(4)
-0.444	2.74f	107.05s	290.00	0.00	-6.722s	-288.62	-16.23(4)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(4) DECK CORNER SB	60.00f	12.00s	8.00

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**********************************************
*             CASE 4                         *
*   DAMAGE TO TANK 33 AND 43                 *
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WEIGHT and DISPLACEMENT STATUS

Origin Depth: -3.955, Trim: Fwd 0.95/120.00, Heel: Stbd 174.29 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	1.00s	12.42
Total Weight-------->	290.00	0.00	0.69s	9.96

Part		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	325.90	2.15f	1.15s	5.95	3.96
TANK33.S	Flooded	1.025	-18.18	28.03f	8.11s	5.47	3.96
TANK43.S	Flooded	1.025	-17.72	12.03f	8.11s	5.53	3.96
Total Displacement-->		1.025	290.00	0.08a	0.29s	6.00	
Righting Arms:				0.05a	0.00s		

Distances in FEET.

Origin Depth: -3.955, Trim: Fwd 0.95/120.00, Heel: Stbd 174.29 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	-2.34
(2) DECK CORNER SS	60.00a	12.00s	8.00	-4.72
(3) DECK CORNER PB	60.00f	12.00p	8.00	-3.28
(4) DECK CORNER SB	60.00f	12.00s	8.00	-5.67

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*                CASE 5                     *
*    DAMAGE TO TANK 43 AND 53               *
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WEIGHT and DISPLACEMENT STATUS

Baseline draft: 4.270 @ Origin. Trim: Fwd 0.39/120.00. Heel: Stbd 16.10 deg.

Part	Weight(LT)	LCG	TCG	VCG
LIGHT SHIP	90.00	0.00	0.00	4.50
CARGO	200.00	0.00	1.00s	12.42
Total Weight-------->	290.00	0.00	0.69s	9.96

		SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL		1.025	325.68	0.90f	3.40s	2.70	-4.10
TANK43.S	Flooded	1.025	-23.84	12.01f	8.23s	3.34	-4.10
TANK53.S	Flooded	1.025	-11.85	0.00	8.23s	3.32	-4.10
Total Displacement-->		1.025	289.99	0.03f	2.81s	2.62	
	Righting Arms:			0.00	0.00s		

Distances in FEET.

Baseline draft: 4.270 @ Origin. Trim: Fwd 0.39/120.00. Heel: Stbd 16.10 deg.

Critical Points	Long.	Trans.	Vert.	Height
(1) DECK CORNER PS	60.00a	12.00p	8.00	7.11
(2) DECK CORNER SS	60.00a	12.00s	8.00	0.45
(3) DECK CORNER PB	60.00f	12.00p	8.00	6.71
(4) DECK CORNER SB	60.00f	12.00s	8.00	0.06

HYDROSTATIC PROPERTIES WITH DAMAGE

Trim: Fwd 0.39/120.00. Heel: Stbd 16.10 deg.. VCG = 9.96

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ IN trim	GML	GMT
4.269	289.99	0.03f	2.62	6.34	0.41a	60.32	299.5	5.42

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Trim is per 120.00Ft

Draft is from Baseline.

RIGHTING ARMS vs HEEL ANGLE with DAMAGE

LCG = 0.00 TCG = 0.69s VCG = 9.96

Origin Depth	Degrees of Trim	Heel	Displacement Weight(LT)	Righting Arms in Trim	in Heel	--> Area	Critical Height
4.103	0.19f	16.10s	289.99	0.00	0.001s	0.00	0.06(4)
4.068	0.21f	18.60s	289.99	0.01f	0.219s	0.00	-0.53(4)
4.050	0.24f	21.10s	290.00	0.00	0.348s	0.73	-1.15(4)
4.038	0.26f	22.58s	290.00	0.01f	0.364s	1.25	-1.53(4)
3.995	0.31f	26.10s	290.01	0.00	0.272s	2.43	-2.41(4)
3.916	0.36f	30.47s	290.00	0.01a	0.000s	3.11	-3.48(4)
3.902	0.37f	31.10s	290.01	0.00	-0.048s	3.10	-3.64(4)
3.771	0.43f	36.10s	290.01	0.00	-0.486s	1.76	-4.83(4)
3.603	0.48f	41.10s	290.00	0.00	-0.985s	-1.89	-5.97(4)
3.407	0.53f	46.10s	290.00	0.00	-1.518s	-8.13	-7.06(4)
3.185	0.58f	51.10s	290.00	0.00	-2.068s	-17.09	-8.10(4)
2.938	0.62f	56.10s	290.00	0.00	-2.621s	-28.82	-9.08(4)
2.670	0.65f	61.10s	290.00	0.00	-3.166s	-43.29	-9.99(4)
2.381	0.68f	66.10s	290.00	0.00	-3.696s	-60.45	-10.82(4)
2.073	0.70f	71.10s	290.00	0.00	-4.204s	-80.21	-11.57(4)
1.750	0.72f	76.10s	290.00	0.00	-4.684s	-102.44	-12.23(4)
1.414	0.73f	81.10s	290.00	0.00	-5.131s	-126.99	-12.80(4)
1.067	0.73f	86.10s	290.00	0.01a	-5.540s	-153.68	-13.26(4)
0.713	0.73f	91.10s	290.02	0.00	-5.908s	-182.32	-13.63(4)
0.349	0.73f	96.10s	289.95	0.01f	-6.231s	-212.68	-13.90(4)
-0.012	0.71f	101.10s	290.00	0.00	-6.505s	-244.54	-14.05(4)
-0.375	0.69f	106.10s	290.00	0.00	-6.727s	-277.64	-14.09(4)

Distances in FEET.-------Specific Gravity = 1.025.------------Area in Ft-Deg.

Critical Point	Long.	Trans.	Vert.
(4) DECK CORNER SB	60.00f	12.00s	8.00

APPENDIX G

Resistance Calculations

Application: Resistance   11 Oct 95 9:33   Page 1
Hull type : Displacement   File name: 969_290.nc3
Description:

---------- Analysis parameters ----------

[X]Bare-hull: Basic
Technique: Prediction
Cf type : ITTC
Align to :
File :
Correlation allow(Ca): 0.00040
[ ]Roughness:
[ ]3-D corr : Form factor(1+k): 0.0000

[ ]Appendage:
[ ]Wind :
[ ]Seas :
[ ]Channel :
[ ]Barge :
[ ]Net :

Cr values from SNAME resistance data sheets

---------- Prediction results ----------

Vel kts	Fn	Rn	Cf	[Cform]	[Cw]	Cr	Ct
1.00	0.028	1.51e7	0.002797	0.000000	0.000000	0.008210	0.011407
2.00	0.056	3.02e7	0.002498	0.000000	0.000000	0.008210	0.011108
3.00	0.083	4.53e7	0.002345	0.000000	0.000000	0.008210	0.010955
4.00	0.111	6.03e7	0.002244	0.000000	0.000000	0.008210	0.010854
5.00	0.139	7.54e7	0.002171	0.000000	0.000000	0.007970	0.010541
6.00	0.167	9.05e7	0.002114	0.000000	0.000000	0.007990	0.010504
7.00	0.195	1.06e8	0.002067	0.000000	0.000000	0.008240	0.010707
8.00	0.223	1.21e8	0.002028	0.000000	0.000000	0.008820	0.011248

Vel kts	Rw/W	Rr/W	Rbare/W	Rw lbs	Rr lbs	Rbare lbs	PEbare hp
1.00	0.00000	0.00013	0.00018	0	84	117	0.4
2.00	0.00000	0.00052	0.00070	0	337	456	2.8
3.00	0.00000	0.00117	0.00156	0	759	1012	9.3
4.00	0.00000	0.00208	0.00275	0	1349	1783	21.9
5.00	0.00000	0.00315	0.00417	0	2046	2706	41.5
6.00	0.00000	0.00455	0.00598	0	2954	3883	71.5
7.00	0.00000	0.00638	0.00829	0	4146	5388	115.7
8.00	0.00000	0.00892	0.01138	0	5797	7392	181.5

Vel kts	Rapp lbs	Rwind lbs	Rseas lbs	Rchan lbs	Rother lbs	Rtotal lbs	PEtotal hp
1.00	0	0	0	0	0	117	0.4
2.00	0	0	0	0	0	456	2.8
3.00	0	0	0	0	0	1012	9.3
4.00	0	0	0	0	0	1783	21.9
5.00	0	0	0	0	0	2706	41.5
6.00	0	0	0	0	0	3883	71.5
7.00	0	0	0	0	0	5388	115.7
8.00	0	0	0	0	0	7392	181.5

969_290.rpd.

Description:

---------- Condition data ----------

Water type: Standard salt
Mass density: 1.9905 slug/ft3
Kinematic visc: 1.27908e-05 ft2/s

---------- Hull data ----------

Primary:		Secondary:	
Length between PP:	120.000 ft	Trim by stern:	0.000 ft
WL aft of FP:	0.000 ft	LCB aft of FP:	0.000 ft
Length on WL:	114.330 ft	Bulb ext fwd FP:	0.000 ft
Max beam on WL:	24.000 ft	Bulb area at FP:	0.000 ft2
Draft at mid WL:	3.875 ft	Bulb ctr abv BL:	0.000 ft
Displacement bare:	290.0 LT	Transom area:	0.000 ft2
Max area coef(Cx):	1.000	Half ent angle:	0.000 deg
Waterplane coef:	1.000	Stern shape:	Normal
Wetted surface:	3622.0 ft2	Bow shape:	Normal
Loading:	Load draft		

Parameters: Basic

Fn(Lwl)	[0.00..0.40]	0.03
Fn-high	[0.00..0.40]	0.22
Displ:Lwl	[20.0..400.0]	194.1

---------- Appendages ----------

Total wetted surface (ex. thruster):

Rudders:	0.000 ft2	Drag coefficient:	0.000
Shaft brackets:	0.000	....	0.000
Skeg:	0.000	....	0.000
Strut bossing:	0.000	....	0.000
Hull bossing:	0.000	....	0.000
Exposed shafts:	0.000	....	0.000
Stabilizer fins:	0.000	....	0.000
Dome:	0.000	....	0.000
Bilge keels:	0.000	....	0.000
Bow thruster diam:	0.000 ft	....	0.000

Description:

---------- Environment data ----------

Wind:		Seas:	
Wind speed:	0.000 kts	Sig. wave height:	0.000 ft
Angle off bow:	0.000 deg	Modal wave period:	0.000 sec
Tran hull area:	0.000 ft2		
VCE above WL:	0.000 ft	Channel:	
Tran superst area:	0.000 ft2	Channel width:	0.000 ft
VCE above WL:	0.000 ft	Channel depth:	0.000 ft
Total longl area:	0.000 ft2	Side slope:	0.000 deg
VCE above WL:	0.000 ft	Wetted hull girth:	0.000 ft
Wind speed:	Free stream		
Arrangement:	Cargo ship		

---------- Symbols and values ----------

Vel	Ship speed
Fn	Froude number
Rn	Reynolds number
Cf	Frictional resistance coefficient
[Cform]	Viscous form resistance coefficient
[Cw]	Wave-making resistance coefficient
Cr	Residuary resistance coefficient
Ct	Bare-hull resistance coefficient
Rw/W	Wave-making resist-displ merit ratio
Rr/W	Residuary resist-displ merit ratio
Rbare/W	Bare-hull resist-displ merit ratio
Rw	Wave-making resistance component
Rr	Residuary resistance component
Rbare	Bare-hull resistance
PEbare	Bare-hull effective power
Rapp	Additional appendage resistance
Rwind	Additional wind resistance
Rseas	Additional sea-state resistance
Rchan	Additional channel resistance
Rother	Other added resistance
Rtotal	Total vessel resistance
PEtotal	Total effective power
*	Exceeds speed parameter

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Calculation Sheet

Project No.:	969-2	Prepared By:	M.D.	Date:	
Title:	ACB Lighter Development	Checked By:		Date:	
Subject:	Hydrodynamics Comparison Analysis			Sheet	of

EFFECT OF CATAMARAN FORM ON RESISTANCE

References : Barge Model Resistance Data Sheets, The Society of Naval Architects and Marine Engineers (SNAME), 1973

Dai, R.Y.T, et. al., "Offshore Construction Barge Performance in Towage Operations", Offshore Technology Conference, OTC 81, Houston, 1981

Resistance Estimate for monohull at unloaded Draft

From the SNAME data sheets on chosen reference barge form, CR ranges from

0.0079 to 0.0088

for $V/\sqrt{L}$ ranging between

0.19 to 0.75

Assume these values are applicable to the full load 120 ft ACB barge with

$$B/T = 24/3.875 = 6.2$$

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Calculation Sheet

Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject: Sheet of.

For the unload ACB barge

$$B/T = 24/1.242 = 19.3$$

From Dai, the trend in Cp for changing B/T results in an estimate of Cp at the higer B/T of about 30% of the Cp at lower B/T.

∴ Use Cp range

0.00246 to 0.00265

for the unloaded monohull.

The following NAVCAD output documents the resistance prediction at these conditions

Resulting total resistance at 6 knots

$$\boxed{R_T \cong 1400 \text{ pounds}}$$

The displacement ration to full load

$$\Delta_{unloaded} / \Delta_{full\,load} = 90/290 = 31\%$$

resistance ratio. $R_{unloaded} / R_{full\,load} = 1400/3800 \cong 37\%$

∴ prediction is reasonable

Application: Resistance 8 Nov 95 14:37 Page 1
Hull type : Displacement File name: 969_90.nc3
Description:

---------- Analysis parameters --

[X]Bare-hull: Basic [ ]Appendage:
Technique: Prediction [ ]Wind :
Cf type : ITTC [ ]Seas :
Align to : [ ]Channel :
File : [ ]Barge :
Correlation allow(Ca): 0.00040 [ ]Net :
[ ]Roughness:
[ ]3-D corr : Form factor(1+k): 0.0000

---------- Prediction results --

Vel kts	Fn	Rn	Cf	[Cform]	[Cw]	Cr	Ct
1.00	0.029	1.42e7	0.002827	0.000000	0.000000	0.002463	0.005690
2.00	0.057	2.83e7	0.002523	0.000000	0.000000	0.002463	0.005386
3.00	0.086	4.25e7	0.002368	0.000000	0.000000	0.002463	0.005231
4.00	0.115	5.66e7	0.002266	0.000000	0.000000	0.002463	0.005129
5.00	0.144	7.08e7	0.002192	0.000000	0.000000	0.002391	0.004983
6.00	0.172	8.50e7	0.002133	0.000000	0.000000	0.002397	0.004930
7.00	0.201	9.91e7	0.002086	0.000000	0.000000	0.002472	0.004958
8.00	0.230	1.13e8	0.002046	0.000000	0.000000	0.002646	0.005092

Vel kts	Rw/W	Rr/W	Rbare/W	Rw lbs	Rr lbs	Rbare lbs	PEbare hp
1.00	0.00000	0.00010	0.00023	0	20	45	0.1
2.00	0.00000	0.00039	0.00085	0	79	172	1.1
3.00	0.00000	0.00088	0.00187	0	177	376	3.5
4.00	0.00000	0.00156	0.00325	0	315	656	8.1
5.00	0.00000	0.00237	0.00494	0	478	996	15.3
6.00	0.00000	0.00342	0.00704	0	690	1419	26.1
7.00	0.00000	0.00480	0.00963	0	968	1942	41.7
8.00	0.00000	0.00671	0.01292	0	1353	2605	63.9

Vel kts	Rapp lbs	Rwind lbs	Rseas lbs	Rchan lbs	Rother lbs	Rtotal lbs	PEtotal hp
1.00	0	0	0	0	0	45	0.1
2.00	0	0	0	0	0	172	1.1
3.00	0	0	0	0	0	376	3.5
4.00	0	0	0	0	0	656	8.1
5.00	0	0	0	0	0	996	15.3
6.00	0	0	0	0	0	1419	26.1
7.00	0	0	0	0	0	1942	41.7
8.00	0	0	0	0	0	2605	63.9

Description:

---------- Condition data ----------

Water type: Standard salt
Mass density: 1.9905 slug/ft3
Kinematic visc: 1.27908e-05 ft2/s

---------- Hull data ----------

Primary:		Secondary:	
Length between PP:	120.000 ft	Trim by stern:	0.000 ft
WL aft of FP:	0.000 ft	LCB aft of FP:	0.000 ft
Length on WL:	107.310 ft	Bulb ext fwd FP:	0.000 ft
Max beam on WL:	24.000 ft	Bulb area at FP:	0.000 ft2
Draft at mid WL:	1.242 ft	Bulb ctr abv BL:	0.000 ft
Displacement bare:	90.0 LT	Transom area:	0.000 ft2
Max area coef(Cx):	1.000	Half ent angle:	0.000 deg
Waterplane coef:	1.000	Stern shape:	Normal
Wetted surface:	2819.0 ft2	Bow shape:	Normal
Loading:	Load draft		

Parameters: Basic

Fn(Lwl)	[0.00..0.40]	0.03
Fn-high	[0.00..0.40]	0.23
Displ:Lwl	[20.0..400.0]	72.8

---------- Appendages ----------

Total wetted surface (ex. thruster):

Rudders:	0.000 ft2	Drag coefficient:	0.000
Shaft brackets:	0.000	....	0.000
Skeg:	0.000	....	0.000
Strut bossing:	0.000	....	0.000
Hull bossing:	0.000	....	0.000
Exposed shafts:	0.000	....	0.000
Stabilizer fins:	0.000	....	0.000
Dome:	0.000	....	0.000
Bilge keels:	0.000	....	0.000
Bow thruster diam:	0.000 ft	....	0.000

---------- Environment data --

Wind:		Seas:	
Wind speed:	0.000 kts	Sig. wave height:	0.000 ft
Angle off bow:	0.000 deg	Modal wave period:	0.000 sec
Tran hull area:	0.000 ft2		
VCE above WL:	0.000 ft	Channel:	
Tran superst area:	0.000 ft2	Channel width:	0.000 ft
VCE above WL:	0.000 ft	Channel depth:	0.000 ft
Total longl area:	0.000 ft2	Side slope:	0.000 deg
VCE above WL:	0.000 ft	Wetted hull girth:	0.000 ft
Wind speed:	Free stream		
Arrangement:	Cargo ship		

---------- Symbols and values --------------------------------------

Vel	Ship speed
Fn	Froude number
Rn	Reynolds number
Cf	Frictional resistance coefficient
[Cform]	Viscous form resistance coefficient
[Cw]	Wave-making resistance coefficient
Cr	Residuary resistance coefficient
Ct	Bare-hull resistance coefficient
Rw/W	Wave-making resist-displ merit ratio
Rr/W	Residuary resist-displ merit ratio
Rbare/W	Bare-hull resist-displ merit ratio
Rw	Wave-making resistance component
Rr	Residuary resistance component
Rbare	Bare-hull resistance
PEbare	Bare-hull effective power
Rapp	Additional appendage resistance
Rwind	Additional wind resistance
Rseas	Additional sea-state resistance
Rchan	Additional channel resistance
Rother	Other added resistance
Rtotal	Total vessel resistance
PEtotal	Total effective power
*	Exceeds speed parameter

Hullform Characteristics for Monohull ACB at unloaded condition

95-11-08 10:07
BHS 5.14

ACB 120 feet module

Page 1
ACB120

WEIGHT and DISPLACEMENT STATUS
Baseline draft: 1.242. Heel: zero

Part		Weight(LT)	LCG	TCG	VCG	
Total Weight-------->		90.00	0.00	0.00	0.00	
	SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL	1.025	90.00	0.00	0.00	0.63	-1.24
Righting Arms:			0.00	0.00		

Distances in FEET.

HYDROSTATIC PROPERTIES
No Trim, No Heel, VCG = 0.00

LCF Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	VCB	Weight/ Inch	LCF	Moment/ Deg trim	GML	GMT
1.242	90.00	0.00	0.63	6.13	0.00	1233.40	785.1	39.86

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Draft is from Baseline.

Part: HULL Component: HULL.C Side: CL Effectiveness: 1.000

Origin Depth: 1.242 Trim: zero Heel: zero

HULL.C COMPONENT FORM

Volume = 3151 Cubic Ft LCB = 0.00 TCB = 0.00 VCB = 0.63
Wetted Surface: 2819 Square Ft

B L O C K D I M E N S I O N S
Length = 107.31 Breadth = 24.00 Depth (deepest point) = 1.24
Length/Breadth = 4.47 Length/Depth = 86.37 Breadth/Depth = 19.316
Breadth - Length/10 = 13.27 Ft Block Coefficient = 0.985
Displacement-Length Ratio = 72.8 Length-Volume Ratio = 7.32

W A T E R P L A N E
Area = 2575.5 Square Ft LCA = 0.00 TCA = 0.00
Moments of Inertia: IL = 2.472E+06 Ft^4 IT = 1.236E+05 Ft^4
Length = 107.31 Breadth = 24.00 Waterplane Coefficient = 1.000

M A X I M U M S E C T I O N
Area = 29.82 Square Ft Coefficient = 1.000

P R I S M A T I C C O E F F I C I E N T S
Cp = 0.985 Cvp = 0.985

Part: HULL Component: HULL.C Side: CL Effectiveness: 1.000
Origin Depth: 1.242 Trim: zero Heel: zero

HULL.C COMPONENT SECTIONS

Section Location	Baseline Depth	Section Area	Section TCtr	Section VCtr	Waterline Width	Waterline Ctr
60.00f	1.24					
...						
53.66f	1.24	0.00	0.00	1.24	24.00	0.00
52.00f	1.24	29.82	0.00	0.62	24.00	0.00
48.00f	1.24	29.82	0.00	0.62	24.00	0.00
44.00f	1.24	29.82	0.00	0.62	24.00	0.00
40.00f	1.24	29.82	0.00	0.62	24.00	0.00
36.00f	1.24	29.82	0.00	0.62	24.00	0.00
32.00f	1.24	29.82	0.00	0.62	24.00	0.00
28.00f	1.24	29.82	0.00	0.62	24.00	0.00
24.00f	1.24	29.82	0.00	0.62	24.00	0.00
20.00f	1.24	29.82	0.00	0.62	24.00	0.00
15.00f	1.24	29.82	0.00	0.62	24.00	0.00
10.00f	1.24	29.82	0.00	0.62	24.00	0.00
5.00f	1.24	29.82	0.00	0.62	24.00	0.00
0.00	1.24	29.82	0.00	0.62	24.00	0.00
5.00a	1.24	29.82	0.00	0.62	24.00	0.00
10.00a	1.24	29.82	0.00	0.62	24.00	0.00
15.00a	1.24	29.82	0.00	0.62	24.00	0.00
20.00a	1.24	29.82	0.00	0.62	24.00	0.00
24.00a	1.24	29.82	0.00	0.62	24.00	0.00
28.00a	1.24	29.82	0.00	0.62	24.00	0.00
32.00a	1.24	29.82	0.00	0.62	24.00	0.00
36.00a	1.24	29.82	0.00	0.62	24.00	0.00
40.00a	1.24	29.82	0.00	0.62	24.00	0.00
44.00a	1.24	29.82	0.00	0.62	24.00	0.00
48.00a	1.24	29.82	0.00	0.62	24.00	0.00
52.00a	1.24	29.82	0.00	0.62	24.00	0.00
53.66a	1.24	0.00	0.00	1.24	24.00	0.00
...						
60.00a	1.24					

Distances in FEET.

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Calculation Sheet

Project No.: Prepared By: Date:

Title: Checked By: Date:

Subject: Sheet of

Resistance Estimate for Catamaran at Unloaded Draft

L/B for full load 120 ft ACB barge

$L/B = 114/24 = 4.75$

L/B for demihull of 120 ft catamaran ACB at unloaded draft

$L/B = 109/8 = 13.6$

From DnI, the trend in C_R for changing L/B results in an estimate of C_R at higher L/B of about 30% of C_R for lower L/B

∴ Use C_R range of

0.00291 to 0.00265 for

the unloaded catamaran demihull

The following NAVCAD output documents the resistance for a demihull at these conditions

Demihull resistance at 6 knot 630 pounds

Total catamaran resistance at 6 knots $\boxed{\text{1260 pounds}}$

KVÆRNER

Application: Resistance 8 Nov 95 16:07
Hull type : Displacement File name: 969_90c.nc3
Description:

---------- Analysis parameters ----------

[X]Bare-hull: Basic
Technique: Prediction
Cf type : ITTC
Align to :
File :
Correlation allow(Ca): 0.00040
[ ]Roughness:
[ ]3-D corr : Form factor(1+k): 0.0000

[ ]Appendage:
[ ]Wind :
[ ]Seas :
[ ]Channel :
[ ]Barge :
[ ]Net :

---------- Prediction results ----------

Vel kts	Fn	Rn	Cf	[Cform]	[Cw]	Cr	Ct
1.00	0.029	1.44e7	0.002819	0.000000	0.000000	0.002463	0.005682
2.00	0.057	2.87e7	0.002517	0.000000	0.000000	0.002463	0.005380
3.00	0.086	4.31e7	0.002362	0.000000	0.000000	0.002463	0.005225
4.00	0.114	5.75e7	0.002261	0.000000	0.000000	0.002463	0.005124
5.00	0.143	7.19e7	0.002187	0.000000	0.000000	0.002391	0.004978
6.00	0.171	8.62e7	0.002129	0.000000	0.000000	0.002397	0.004926
7.00	0.200	1.01e8	0.002081	0.000000	0.000000	0.002472	0.004953
8.00	0.228	1.15e8	0.002042	0.000000	0.000000	0.002646	0.005088

Vel kts	Rw/W	Rr/W	Rbare/W	Rw lbs	Rr lbs	Rbare lbs	PEbare hp
1.00	0.00000	0.00009	0.00020	0	9	20	0.1
2.00	0.00000	0.00035	0.00076	0	35	76	0.5
3.00	0.00000	0.00078	0.00166	0	79	167	1.5
4.00	0.00000	0.00139	0.00289	0	140	291	3.6
5.00	0.00000	0.00211	0.00439	0	212	442	6.8
6.00	0.00000	0.00304	0.00625	0	307	630	11.6
7.00	0.00000	0.00427	0.00855	0	430	862	18.5
8.00	0.00000	0.00597	0.01148	0	602	1157	28.4

Vel kts	Rapp lbs	Rwind lbs	Rseas lbs	Rchan lbs	Rother lbs	Rtotal lbs	PEtotal hp
1.00	0	0	0	0	0	20	0.1
2.00	0	0	0	0	0	76	0.5
3.00	0	0	0	0	0	167	1.5
4.00	0	0	0	0	0	291	3.6
5.00	0	0	0	0	0	442	6.8
6.00	0	0	0	0	0	630	11.6
7.00	0	0	0	0	0	862	18.5
8.00	0	0	0	0	0	1157	28.4

Description:

---------- Condition data ----------

Water type: Standard salt
Mass density: 1.9905 slug/ft3
Kinematic visc: 1.27908e-05 ft2/s

---------- Hull data ----------

Primary:		Secondary:	
Length between PP:	120.000 ft	Trim by stern:	0.000 ft
WL aft of FP:	0.000 ft	LCB aft of FP:	0.000 ft
Length on WL:	108.930 ft	Bulb ext fwd FP:	0.000 ft
Max beam on WL:	8.000 ft	Bulb area at FP:	0.000 ft2
Draft at mid WL:	1.850 ft	Bulb ctr abv BL:	0.000 ft
Displacement bare:	45.0 LT	Transom area:	0.000 ft2
Max area coef(Cx):	1.000	Half ent angle:	0.000 deg
Waterplane coef:	1.000	Stern shape:	Normal
Wetted surface:	1253.0 ft2	Bow shape:	Normal
Loading:	Load draft		

Parameters: Basic

Fn(Lwl)	[0.00..0.40]	0.03
Fn-high	[0.00..0.40]	0.23
Displ:Lwl	[20.0..400.0]	34.8

---------- Appendages ----------

Total wetted surface (ex. thruster):

Rudders:	0.000 ft2	Drag coefficient:	0.000
Shaft brackets:	0.000	....	0.000
Skeg:	0.000	....	0.000
Strut bossing:	0.000	....	0.000
Hull bossing:	0.000	....	0.000
Exposed shafts:	0.000	....	0.000
Stabilizer fins:	0.000	....	0.000
Dome:	0.000	....	0.000
Bilge keels:	0.000	....	0.000
Bow thruster diam:	0.000 ft	....	0.000

Description:

--------- Environment data ---------

Wind:

Wind speed:	0.000 kts
Angle off bow:	0.000 deg
Tran hull area:	0.000 ft2
VCE above WL:	0.000 ft
Tran superst area:	0.000 ft2
VCE above WL:	0.000 ft
Total longl area:	0.000 ft2
VCE above WL:	0.000 ft
Wind speed:	Free stream
Arrangement:	Cargo ship

Seas:

Sig. wave height:	0.000 ft
Modal wave period:	0.000 sec

Channel:

Channel width:	0.000 ft
Channel depth:	0.000 ft
Side slope:	0.000 deg
Wetted hull girth:	0.000 ft

--------- Symbols and values ---------

Vel	Ship speed
Fn	Froude number
Rn	Reynolds number
Cf	Frictional resistance coefficient
[Cform]	Viscous form resistance coefficient
[Cw]	Wave-making resistance coefficient
Cr	Residuary resistance coefficient
Ct	Bare-hull resistance coefficient
Rw/W	Wave-making resist-displ merit ratio
Rr/W	Residuary resist-displ merit ratio
Rbare/W	Bare-hull resist-displ merit ratio
Rw	Wave-making resistance component
Rr	Residuary resistance component
Rbare	Bare-hull resistance
PEbare	Bare-hull effective power
Rapp	Additional appendage resistance
Rwind	Additional wind resistance
Rseas	Additional sea-state resistance
Rchan	Additional channel resistance
Rother	Other added resistance
Rtotal	Total vessel resistance
PEtotal	Total effective power
*	Exceeds speed parameter

--Hullform Characteristics for catamaran ACB at unloaded draft

95-11-08 11:26 Page 1
BHS 5.14 ACB 120 feet module ACB120C

WEIGHT and DISPLACEMENT STATUS
Baseline draft: 1.850. Heel: zero

Part		Weight(LT)	LCG	TCG	VCG	
Total Weight-------->		90.00	0.00	0.00	0.00	
	SpGr	Displ(LT)	LCB	TCB	VCB	Ref Ht
HULL	1.025	90.00	0.00	0.00	0.94	-1.85
Righting Arms:			0.00	0.00		

Distances in FEET.

HYDROSTATIC PROPERTIES
No Trim. No Heel. VCG = 0.00

Draft	Displacement Weight(LT)	Buoyancy Ctr. LCB	Buoyancy Ctr. VCB	Weight/ Inch	LCF	Moment/ Deg trim	GML	GMT
1.850	90.00	0.00	0.94	4.15	0.00	860.83	548.0	38.61

Distances in FEET.--------Specific Gravity = 1.025.-----------Moment in Ft-LT.
Draft is from Baseline.

Part: HULL Component: HULL.C Side: CL Effectiveness: 1.000

Origin Depth: 1.850 Trim: zero Heel: zero

HULL.C COMPONENT FORM

Volume = 3151 Cubic Ft LCB = 0.00 TCB = 0.00 VCB = 0.94
Wetted Surface: 2507 Square Ft

B L O C K D I M E N S I O N S
Length = 108.93 Breadth = 24.00 Depth (deepest point) = 1.85
Length/Breadth = 4.54 Length/Depth = 58.90 Breadth/Depth = 12.976
Breadth - Length/10 = 13.11 Ft Block Coefficient = 0.652
Displacement-Length Ratio = 69.6 Length-Volume Ratio = 7.43

W A T E R P L A N E
Area = 1742.9 Square Ft LCA = -0.00 TCA = 0.00
Moments of Inertia: IL = 1.723E+06 Ft^4 IT = 1.187E+05 Ft^4
Length = 108.93 Breadth = 16.00 Waterplane Coefficient = 1.000

M A X I M U M S E C T I O N
Area = 29.59 Square Ft Coefficient = 0.667

P R I S M A T I C C O E F F I C I E N T S
Cp = 0.977 Cvp = 0.977

Part: HULL Component: HULL.C Side: CL Effectiveness: 1.000
Origin Depth: 1.850 Trim: zero Heel: zero

HULL.C COMPONENT SECTIONS

Section Location	Baseline Depth	Section Area	TCtr	VCtr	Waterline Width	Ctr
60.00f	1.85					
...						
54.47f	1.85	0.00	0.00	1.85	16.00	0.00
52.00f	1.85	29.59	0.00	0.92	16.00	0.00
48.00f	1.85	29.59	0.00	0.92	16.00	0.00
44.00f	1.85	29.59	0.00	0.92	16.00	0.00
40.00f	1.85	29.59	0.00	0.92	16.00	0.00
36.00f	1.85	29.59	0.00	0.92	16.00	0.00
32.00f	1.85	29.59	0.00	0.92	16.00	0.00
28.00f	1.85	29.59	0.00	0.92	16.00	0.00
24.00f	1.85	29.59	0.00	0.92	16.00	0.00
20.00f	1.85	29.59	0.00	0.92	16.00	0.00
15.00f	1.85	29.59	0.00	0.92	16.00	0.00
10.00f	1.85	29.59	0.00	0.92	16.00	0.00
5.00f	1.85	29.59	0.00	0.92	16.00	0.00
0.00	1.85	29.59	0.00	0.92	16.00	0.00
5.00a	1.85	29.59	0.00	0.92	16.00	0.00
10.00a	1.85	29.59	0.00	0.92	16.00	0.00
15.00a	1.85	29.59	0.00	0.92	16.00	0.00
20.00a	1.85	29.59	0.00	0.92	16.00	0.00
24.00a	1.85	29.59	0.00	0.92	16.00	0.00
28.00a	1.85	29.59	0.00	0.92	16.00	0.00
32.00a	1.85	29.59	0.00	0.92	16.00	0.00
36.00a	1.85	29.59	0.00	0.92	16.00	0.00
40.00a	1.85	29.59	0.00	0.92	16.00	0.00
44.00a	1.85	29.59	0.00	0.92	16.00	0.00
48.00a	1.85	29.59	0.00	0.92	16.00	0.00
52.00a	1.85	29.59	0.00	0.92	16.00	0.00
54.47a	1.85	0.00	0.00	1.85	16.00	0.00
...						
60.00a	1.85					

Distances in FEET.

Kvaerner Masa Marine Inc.

☐ Vancouver, B.C. ☐ Annapolis, MD.

Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

Conclusions

The results of the comparison between monohull and catamaran resistances at an unloaded draft condition indicate that about a 10% decrease in resistance can be expected.

This resistance is primarily due to the fact that the wetted surface for the catamaran hull is smaller for the same displacement

KVÆRNER

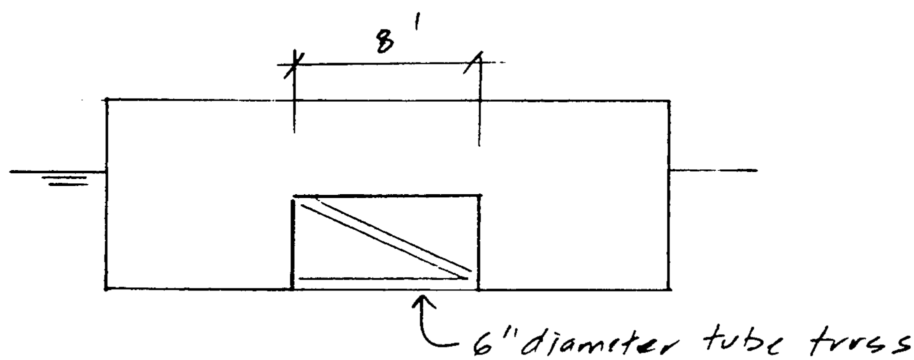
Kvaerner Masa Marine Inc.

☐ Vancouver, B.C. ☐ Annapolis, MD. **Calculation Sheet**

Project No.: 969-2	Prepared By: M.D	Date:	
Title: ACB Lighter Development	Checked By:	Date:	
Subject: Hydrodynamics Comparison Analysis		Sheet	of

EFFECT OF TRUSS SYSTEM ON RESISTANCE

Reference : "Principles of Naval Architecture", Volume II, E.V. Lewis, Ed., SNAME, 1988, p.38.



Pressure Drag on a Cylinder

The pressure drag on a cylinder in cross flow is given by

$$D = C_{DP} \frac{1}{2} \rho A V^2$$

where A is the projected area

For a angle of attack of 90° (cylinder perpendicular to the flow)

$$C_{DP} \cong 1.2$$

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Title: Checked By: Date:

Subject: Sheet of

Therefore for one horizontal member of the truss at 6 knots speed:

$\rho = 1.99 \ lb \ s^2/ft^4$

$A = (0.5)(8) = 4 \ ft^2$
$V = (6)(1.689) = 10.13 \ ft/s$

$D = (1.2)(\frac{1}{2})(1.99)^{\frac{lb \cdot \cancel{s^2}}{\cancel{ft^4}}}(4)^{\cancel{ft^2}}(10.13)^2{}^{\cancel{ft^2}/\cancel{s^2}} = 490 \text{ pounds}$

For one diagonal member

$A \cong (0.5)(8^2 + 4^2)^{1/2} = 4.4 \ ft^2$

$D = 539$ pounds

∴ Therefore for one truss only

$D \cong 1029$ pounds

This amounts to approx $\frac{1029}{3800} = 27\%$ of total monohull full load resistance

If consider all trusses along length of 120 foot unit

Trusses have serious detrimental effect

KVÆRNER

Kvaerner Masa Marine Inc.

☐ Vancouver, B.C. ☐ Annapolis, MD. **Calculation Sheet**

Project No.: 969-2	Prepared By: M.D.	Date:	
Title: ACB Lighter Development	Checked By:	Date:	
Subject: Hydrodynamics Comparison Analysis		Sheet	of

EFFECT OF PERFORATED PLATES ON RESISTANCE

Reference: "Principles of Naval Architecture," Vol II, E.V. Lewis, Ed., SNAME, 1988, pp 15-16

Resistance Estimate for a Flat Plate Parallel to the Flow

The PNA reference gives a formula for the frictional resistance coefficient that can be applied to a flat plate.

$$C_f = 0.075 / (\log R_n - 2)^2$$

The frictional drag term is

$$R_f = C_f \tfrac{1}{2} \rho S V^2$$

S = wetted surface area of the plate = (2)(length)(breadth of plate)

For 120 ft length the Reynolds number R_n is approximately

$$R_n = VL/\nu \cong \frac{(6)(1.689)(120)}{1.279 \times 10^{-5}} = 9.5 \times 10^7$$

KVÆRNER

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Calculation Sheet

Project No.:	Prepared By:	Date:
Title:	Checked By:	Date:
Subject:		Sheet of

$$\therefore \quad C_f = 0.075 \Big/ \left(\log\left(9.5 \times 10^7\right) - 2\right)^2$$

$$= 0.0021$$

For two 4 foot deep attached plates on 120 ft barge

$$S \cong (2)(2)(4)(120) = 1920 \text{ ft}^2$$

$$\therefore \quad R_f = (0.0021)\left(\tfrac{1}{2}\right)(1.99)(1920)(10.13)^2$$

$$= \underline{411 \text{ pounds}}$$

This amounts to $411/3800 \cong 11\%$ of total resistance

APPENDIX H

SMP Analysis Documentation

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.55/ 5	0.56/ 5	0.60/ 5	0.66/ 5	0.71/ 5	0.74/ 5	0.75/ 5	0.74/ 5	0.71/ 5	0.66/ 5	0.60/ 5	0.56/ 5	0.55/ 5
	7	0.63/ 6	0.64/ 6	0.66/ 6	0.69/ 6	0.71/ 6	0.73/ 6	0.74/ 6	0.73/ 6	0.71/ 6	0.69/ 6	0.66/ 6	0.64/ 6	0.63/ 6
	9	0.57/ 8	0.57/ 8	0.58/ 8	0.60/ 8	0.61/ 8	0.63/ 8	0.63/ 8	0.63/ 8	0.61/ 8	0.60/ 8	0.58/ 8	0.57/ 8	0.57/ 8
	11	0.47/ 8	0.47/ 8	0.48/ 8	0.49/ 8	0.50/ 8	0.51/ 8	0.51/ 8	0.51/ 8	0.50/ 8	0.49/ 8	0.48/ 8	0.47/ 8	0.47/ 8
	13	0.39/10	0.39/10	0.39/10	0.40/10	0.41/10	0.41/10	0.41/10	0.41/10	0.41/10	0.40/10	0.39/10	0.39/10	0.39/10
	15	0.33/10	0.34/10	0.34/10	0.34/10	0.35/10	0.35/10	0.35/10	0.35/10	0.35/10	0.34/10	0.34/10	0.34/10	0.33/10
	17	0.29/10	0.29/10	0.29/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.29/10	0.29/10	0.29/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.24/ 5	1.24/ 5	1.23/ 5	1.21/ 5	1.19/ 5	1.18/ 5	1.18/ 5	1.18/ 5	1.19/ 5	1.21/ 5	1.23/ 5	1.24/ 5	1.24/ 5
	7	1.48/ 6	1.46/ 6	1.40/ 6	1.31/ 6	1.21/ 6	1.14/ 6	1.11/ 6	1.14/ 6	1.21/ 6	1.31/ 6	1.40/ 6	1.46/ 6	1.48/ 6
	9	1.33/ 8	1.31/ 8	1.24/ 8	1.14/ 8	1.04/ 8	0.95/ 8	0.92/ 8	0.95/ 8	1.04/ 8	1.14/ 8	1.24/ 8	1.31/ 8	1.33/ 8
	11	1.10/ 8	1.07/ 8	1.02/ 8	0.93/ 8	0.83/ 8	0.75/ 8	0.72/ 8	0.75/ 8	0.83/ 8	0.93/ 8	1.02/ 8	1.07/ 8	1.10/ 8
	13	0.90/10	0.88/10	0.83/10	0.76/10	0.68/10	0.61/10	0.58/10	0.61/10	0.68/10	0.76/10	0.83/10	0.88/10	0.90/10
	15	0.77/10	0.75/10	0.71/10	0.64/10	0.57/10	0.51/10	0.49/10	0.51/10	0.57/10	0.64/10	0.71/10	0.75/10	0.77/10
	17	0.66/10	0.65/10	0.61/10	0.55/10	0.49/10	0.43/10	0.41/10	0.43/10	0.49/10	0.55/10	0.61/10	0.65/10	0.66/10

ACB40D2.Duc

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	5.02/ 5	6.21/ 5	8.68/ 5	11.13/ 5	13.00/ 5	14.17/ 5	14.57/ 5	14.17/ 5	13.00/ 5	11.13/ 5	8.68/ 5	6.21/ 5	5.02/ 5
	7	4.03/ 5	4.93/ 5	6.83/ 5	8.78/ 5	10.34/ 5	11.31/ 5	11.64/ 5	11.31/ 5	10.34/ 5	8.78/ 5	6.83/ 5	4.93/ 5	4.03/ 5
	9	2.79/ 5	3.38/ 5	4.63/ 5	5.93/ 5	7.00/ 5	7.69/ 5	7.93/ 5	7.69/ 5	7.00/ 5	5.93/ 5	4.63/ 5	3.38/ 5	2.79/ 5
	11	1.98/ 5	2.39/ 5	3.25/ 5	4.14/ 5	4.88/ 5	5.35/ 5	5.52/ 5	5.35/ 5	4.88/ 5	4.14/ 5	3.25/ 5	2.39/ 5	1.98/ 5
	13	1.47/ 5	1.76/ 5	2.38/ 5	3.04/ 5	3.57/ 5	3.91/ 5	4.03/ 5	3.91/ 5	3.57/ 5	3.04/ 5	2.38/ 5	1.76/ 5	1.47/ 5
	15	1.14/ 5	1.36/ 5	1.83/ 5	2.32/ 5	2.73/ 5	2.99/ 5	3.08/ 5	2.99/ 5	2.73/ 5	2.32/ 5	1.83/ 5	1.36/ 5	1.14/ 5
	17	0.91/ 5	1.08/ 5	1.44/ 5	1.83/ 5	2.15/ 5	2.35/ 5	2.43/ 5	2.35/ 5	2.15/ 5	1.83/ 5	1.44/ 5	1.08/ 5	0.91/ 5

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.48/ 6	0.53/ 6	0.64/ 6	0.77/ 6	0.88/ 5	0.95/ 5	0.98/ 5	0.95/ 5	0.88/ 5	0.77/ 6	0.64/ 6	0.53/ 6	0.48/ 6
	7	0.96/ 8	0.98/ 8	1.05/ 8	1.13/ 8	1.21/ 8	1.26/ 8	1.28/ 8	1.26/ 8	1.21/ 8	1.13/ 8	1.05/ 8	0.98/ 8	0.96/ 8
	9	1.17/10	1.18/10	1.22/10	1.27/10	1.32/ 8	1.36/ 8	1.37/ 8	1.36/ 8	1.32/ 8	1.27/10	1.22/10	1.18/10	1.17/10
	11	1.21/10	1.22/10	1.24/10	1.27/10	1.30/10	1.33/10	1.33/10	1.33/10	1.30/10	1.27/10	1.24/10	1.22/10	1.21/10
	13	1.43/10	1.44/10	1.45/10	1.47/10	1.49/10	1.50/10	1.50/10	1.50/10	1.49/10	1.47/10	1.45/10	1.44/10	1.43/10
	15	1.63/16	1.63/16	1.64/16	1.65/16	1.66/16	1.67/16	1.67/16	1.67/16	1.66/16	1.65/16	1.64/16	1.63/16	1.63/16
	17	1.62/16	1.62/16	1.63/16	1.64/16	1.64/16	1.65/16	1.65/16	1.65/16	1.64/16	1.64/16	1.63/16	1.62/16	1.62/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.53/ 5	0.63/ 5	0.86/ 5	1.10/ 5	1.28/ 5	1.39/ 5	1.43/ 5	1.39/ 5	1.28/ 5	1.10/ 5	0.86/ 5	0.63/ 5	0.53/ 5
	7	0.64/ 5	0.73/ 5	0.93/ 5	1.15/ 5	1.33/ 5	1.44/ 5	1.48/ 5	1.44/ 5	1.33/ 5	1.15/ 5	0.93/ 5	0.73/ 5	0.64/ 5
	9	0.66/ 8	0.73/ 8	0.89/ 8	1.07/ 8	1.22/ 5	1.32/ 5	1.36/ 5	1.32/ 5	1.22/ 5	1.07/ 8	0.89/ 8	0.73/ 8	0.66/ 8
	11	0.64/10	0.69/10	0.83/10	0.98/10	1.11/10	1.20/10	1.23/10	1.20/10	1.11/10	0.98/10	0.83/10	0.69/10	0.64/10
	13	0.72/10	0.77/10	0.91/10	1.06/10	1.19/10	1.28/10	1.32/10	1.28/10	1.19/10	1.06/10	0.91/10	0.77/10	0.72/10
	15	0.80/16	0.86/16	0.99/16	1.16/16	1.30/16	1.39/16	1.43/16	1.39/16	1.30/16	1.16/16	0.99/16	0.86/16	0.80/16
	17	0.79/16	0.85/16	0.98/16	1.14/16	1.28/16	1.37/16	1.40/16	1.37/16	1.28/16	1.14/16	0.98/16	0.85/16	0.79/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5
	7	0.11/ 6	0.11/ 6	0.10/ 6	0.09/ 6	0.09/ 6	0.08/ 6	0.08/ 6	0.08/ 6	0.09/ 6	0.09/ 6	0.10/ 6	0.11/ 6	0.11/ 6
	9	0.10/ 8	0.10/ 8	0.09/ 8	0.08/ 8	0.08/ 8	0.07/ 8	0.07/ 8	0.07/ 8	0.08/ 8	0.08/ 8	0.09/ 8	0.10/ 8	0.10/ 8
	11	0.08/ 8	0.08/ 8	0.07/ 8	0.07/ 8	0.06/ 8	0.05/ 8	0.05/ 8	0.05/ 8	0.06/ 8	0.07/ 8	0.07/ 8	0.08/ 8	0.08/ 8
	13	0.07/10	0.06/10	0.06/10	0.06/10	0.05/10	0.04/10	0.04/10	0.04/10	0.05/10	0.06/10	0.06/10	0.06/10	0.07/10
	15	0.06/10	0.05/10	0.05/10	0.05/10	0.04/10	0.04/10	0.04/10	0.04/10	0.04/10	0.05/10	0.05/10	0.05/10	0.06/10
	17	0.05/10	0.05/10	0.04/10	0.04/10	0.04/10	0.03/10	0.03/10	0.03/10	0.04/10	0.04/10	0.04/10	0.05/10	0.05/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.27/ 6	0.55/ 5	0.81/ 5	0.97/ 5	0.79/ 4	0.00/ 5	0.79/ 4	0.97/ 5	0.81/ 5	0.55/ 5	0.27/ 6	0.00/99
	7	0.00/99	0.37/ 6	0.70/ 6	0.93/ 6	0.95/ 6	0.66/ 6	0.00/ 8	0.66/ 6	0.95/ 6	0.93/ 6	0.70/ 6	0.37/ 6	0.00/99
	9	0.00/99	0.36/ 8	0.66/ 8	0.83/ 8	0.80/ 8	0.52/ 8	0.00/ 8	0.52/ 8	0.80/ 8	0.83/ 8	0.66/ 8	0.36/ 8	0.00/99
	11	0.00/99	0.30/ 8	0.55/ 8	0.68/ 8	0.64/ 8	0.41/ 8	0.00/10	0.41/ 8	0.64/ 8	0.68/ 8	0.55/ 8	0.30/ 8	0.00/99
	13	0.00/99	0.26/10	0.46/10	0.56/10	0.52/10	0.33/10	0.00/10	0.33/10	0.52/10	0.56/10	0.46/10	0.26/10	0.00/99
	15	0.00/99	0.22/10	0.40/10	0.48/10	0.44/10	0.27/10	0.00/16	0.27/10	0.44/10	0.48/10	0.40/10	0.22/10	0.00/99
	17	0.00/99	0.20/10	0.35/10	0.41/10	0.38/10	0.23/10	0.00/16	0.23/10	0.38/10	0.41/10	0.35/10	0.20/10	0.00/99

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.13/ 5	1.16/ 5	1.25/ 5	1.38/ 5	1.45/ 4	1.11/ 4	0.00/ 4	1.11/ 4	1.45/ 4	1.38/ 5	1.25/ 5	1.16/ 5	1.13/ 5
	7	1.53/ 6	1.52/ 6	1.51/ 6	1.45/ 6	1.29/ 6	0.85/ 5	0.00/ 5	0.85/ 5	1.29/ 6	1.45/ 6	1.51/ 6	1.52/ 6	1.53/ 6
	9	1.43/ 8	1.42/ 8	1.36/ 8	1.24/ 8	1.02/ 6	0.63/ 6	0.00/ 5	0.63/ 6	1.02/ 6	1.24/ 8	1.36/ 8	1.42/ 8	1.43/ 8
	11	1.20/ 8	1.18/ 8	1.11/ 8	0.99/ 8	0.79/ 8	0.48/ 8	0.00/10	0.48/ 8	0.79/ 8	0.99/ 8	1.11/ 8	1.18/ 8	1.20/ 8
	13	1.00/10	0.98/10	0.91/10	0.80/10	0.63/ 8	0.37/ 8	0.00/10	0.37/ 8	0.63/ 8	0.80/10	0.91/10	0.98/10	1.00/10
	15	0.86/10	0.84/10	0.78/10	0.67/10	0.52/10	0.30/10	0.00/10	0.30/10	0.52/10	0.67/10	0.78/10	0.84/10	0.86/10
	17	0.74/10	0.72/10	0.67/10	0.57/10	0.44/10	0.25/10	0.00/10	0.25/10	0.44/10	0.57/10	0.67/10	0.72/10	0.74/10

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.49/ 5	1.83/ 5	5.51/ 5	11.73/ 5	17.76/ 5	20.55/ 5	17.76/ 5	11.73/ 5	5.51/ 5	1.83/ 5	0.49/ 5	0.00/99
	7	0.00/99	0.59/ 6	1.74/ 5	4.57/ 5	9.40/ 5	14.12/ 5	16.13/ 5	14.12/ 5	9.40/ 5	4.57/ 5	1.74/ 5	0.59/ 6	0.00/99
	9	0.00/99	0.52/ 6	1.35/ 5	3.23/ 5	6.39/ 5	9.75/ 5	11.18/ 5	9.75/ 5	6.39/ 5	3.23/ 5	1.35/ 5	0.52/ 6	0.00/99
	11	0.00/99	0.42/ 8	1.03/ 5	2.32/ 5	4.48/ 5	6.79/ 5	7.82/ 5	6.79/ 5	4.48/ 5	2.32/ 5	1.03/ 5	0.42/ 8	0.00/99
	13	0.00/99	0.34/ 8	0.81/ 5	1.74/ 5	3.30/ 5	4.95/ 5	5.69/ 5	4.95/ 5	3.30/ 5	1.74/ 5	0.81/ 5	0.34/ 8	0.00/99
	15	0.00/99	0.29/10	0.66/ 5	1.36/ 5	2.53/ 5	3.77/ 5	4.32/ 5	3.77/ 5	2.53/ 5	1.36/ 5	0.66/ 5	0.29/10	0.00/99
	17	0.00/99	0.24/10	0.54/ 5	1.09/ 5	2.00/ 5	2.97/ 5	3.39/ 5	2.97/ 5	2.00/ 5	1.09/ 5	0.54/ 5	0.24/10	0.00/99

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.33/ 6	0.35/ 6	0.41/ 6	0.55/ 6	0.81/ 5	1.16/ 5	1.37/ 5	1.16/ 5	0.81/ 5	0.55/ 6	0.41/ 6	0.35/ 6	0.33/ 6
	7	0.84/ 8	0.86/ 8	0.93/ 8	1.05/ 8	1.22/ 8	1.41/ 6	1.51/ 6	1.41/ 6	1.22/ 8	1.05/ 8	0.93/ 8	0.86/ 8	0.84/ 8
	9	1.09/10	1.10/10	1.16/10	1.24/10	1.34/ 8	1.45/ 8	1.50/ 8	1.45/ 8	1.34/ 8	1.24/10	1.16/10	1.10/10	1.09/10
	11	1.15/10	1.17/10	1.20/10	1.25/10	1.32/10	1.39/10	1.42/10	1.39/10	1.32/10	1.25/10	1.20/10	1.17/10	1.15/10
	13	1.40/10	1.41/10	1.43/10	1.46/10	1.50/10	1.53/10	1.55/10	1.53/10	1.50/10	1.46/10	1.43/10	1.41/10	1.40/10
	15	1.61/16	1.61/16	1.62/16	1.64/16	1.67/16	1.69/16	1.70/16	1.69/16	1.67/16	1.64/16	1.62/16	1.61/16	1.61/16
	17	1.61/16	1.61/16	1.62/16	1.63/16	1.65/16	1.67/16	1.67/16	1.67/16	1.65/16	1.63/16	1.62/16	1.61/16	1.61/16

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1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.10/ 6	0.26/ 6	0.62/ 5	1.19/ 5	1.73/ 5	1.98/ 5	1.73/ 5	1.19/ 5	0.62/ 5	0.26/ 6	0.10/ 6	0.00/99
	7	0.00/99	0.23/ 8	0.49/ 8	0.84/ 8	1.32/ 5	1.76/ 5	1.95/ 5	1.76/ 5	1.32/ 5	0.84/ 8	0.49/ 8	0.23/ 8	0.00/99
	9	0.00/99	0.28/10	0.58/10	0.90/ 8	1.27/ 8	1.59/ 5	1.72/ 5	1.59/ 5	1.27/ 8	0.90/ 8	0.58/10	0.28/10	0.00/99
	11	0.00/99	0.29/10	0.59/10	0.89/10	1.18/10	1.42/10	1.52/10	1.42/10	1.18/10	0.89/10	0.59/10	0.29/10	0.00/99
	13	0.00/99	0.35/10	0.69/10	1.01/10	1.29/10	1.49/10	1.57/10	1.49/10	1.29/10	1.01/10	0.69/10	0.35/10	0.00/99
	15	0.00/99	0.40/16	0.78/16	1.13/16	1.41/16	1.61/16	1.68/16	1.61/16	1.41/16	1.13/16	0.78/16	0.40/16	0.00/99
	17	0.00/99	0.40/16	0.78/16	1.12/16	1.39/16	1.57/16	1.64/16	1.57/16	1.39/16	1.12/16	0.78/16	0.40/16	0.00/99

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.08/ 5	0.08/ 5	0.09/ 5	0.10/ 5	0.10/ 4	0.08/ 4	0.00/ 4	0.08/ 4	0.10/ 4	0.10/ 5	0.09/ 5	0.08/ 5	0.08/ 5
	7	0.11/ 6	0.11/ 6	0.11/ 6	0.11/ 6	0.09/ 6	0.06/ 5	0.00/ 5	0.06/ 5	0.09/ 6	0.11/ 6	0.11/ 6	0.11/ 6	0.11/ 6
	9	0.10/ 8	0.10/ 8	0.10/ 8	0.09/ 8	0.07/ 6	0.05/ 6	0.00/ 5	0.05/ 6	0.07/ 6	0.09/ 8	0.10/ 8	0.10/ 8	0.10/ 8
	11	0.09/ 8	0.09/ 8	0.08/ 8	0.07/ 8	0.06/ 8	0.03/ 8	0.00/10	0.03/ 8	0.06/ 8	0.07/ 8	0.08/ 8	0.09/ 8	0.09/ 8
	13	0.07/10	0.07/10	0.07/10	0.06/10	0.05/ 8	0.03/ 8	0.00/10	0.03/ 8	0.05/ 8	0.06/10	0.07/10	0.07/10	0.07/10
	15	0.06/10	0.06/10	0.06/10	0.05/10	0.04/10	0.02/10	0.00/10	0.02/10	0.04/10	0.05/10	0.06/10	0.06/10	0.06/10
	17	0.05/10	0.05/10	0.05/10	0.04/10	0.03/10	0.02/10	0.00/10	0.02/10	0.03/10	0.04/10	0.05/10	0.05/10	0.05/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.52/ 5	0.53/ 5	0.57/ 5	0.62/ 5	0.67/ 5	0.70/ 5	0.71/ 5	0.70/ 5	0.67/ 5	0.62/ 5	0.57/ 5	0.53/ 5	0.52/ 5
	7	0.59/ 6	0.60/ 6	0.62/ 6	0.65/ 6	0.67/ 6	0.69/ 6	0.70/ 6	0.69/ 6	0.67/ 6	0.65/ 6	0.62/ 6	0.60/ 6	0.59/ 6
	9	0.53/ 7	0.54/ 7	0.55/ 7	0.56/ 7	0.58/ 7	0.59/ 7	0.59/ 7	0.59/ 7	0.58/ 7	0.56/ 7	0.55/ 7	0.54/ 7	0.53/ 7
	11	0.45/ 9	0.45/ 9	0.46/ 9	0.47/ 9	0.48/ 8	0.49/ 8	0.49/ 8	0.49/ 8	0.48/ 8	0.47/ 9	0.46/ 9	0.45/ 9	0.45/ 9
	13	0.38/10	0.38/10	0.38/10	0.39/10	0.40/10	0.40/10	0.40/10	0.40/10	0.40/10	0.39/10	0.38/10	0.38/10	0.38/10
	15	0.32/11	0.32/11	0.32/11	0.32/11	0.33/11	0.33/11	0.33/11	0.33/11	0.33/11	0.32/11	0.32/11	0.32/11	0.32/11
	17	0.27/13	0.27/13	0.27/13	0.27/13	0.28/13	0.28/13	0.28/13	0.28/13	0.28/13	0.27/13	0.27/13	0.27/13	0.27/13

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.31/ 5	1.31/ 5	1.30/ 5	1.28/ 5	1.26/ 5	1.25/ 5	1.25/ 5	1.25/ 5	1.26/ 5	1.28/ 5	1.30/ 5	1.31/ 5	1.31/ 5
	7	1.57/ 6	1.55/ 6	1.49/ 6	1.39/ 6	1.29/ 6	1.21/ 6	1.18/ 6	1.21/ 6	1.29/ 6	1.39/ 6	1.49/ 6	1.55/ 6	1.57/ 6
	9	1.41/ 7	1.39/ 7	1.32/ 7	1.21/ 7	1.10/ 7	1.01/ 7	0.97/ 7	1.01/ 7	1.10/ 7	1.21/ 7	1.32/ 7	1.39/ 7	1.41/ 7
	11	1.19/ 8	1.16/ 8	1.10/ 8	1.00/ 8	0.90/ 8	0.82/ 8	0.78/ 8	0.82/ 8	0.90/ 8	1.00/ 8	1.10/ 8	1.16/ 8	1.19/ 8
	13	0.99/10	0.97/10	0.91/10	0.83/10	0.74/ 9	0.66/ 9	0.63/ 9	0.66/ 9	0.74/ 9	0.83/10	0.91/10	0.97/10	0.99/10
	15	0.82/10	0.80/10	0.76/10	0.69/10	0.61/10	0.54/10	0.52/10	0.54/10	0.61/10	0.69/10	0.76/10	0.80/10	0.82/10
	17	0.69/11	0.67/11	0.63/11	0.57/11	0.51/11	0.45/11	0.43/11	0.45/11	0.51/11	0.57/11	0.63/11	0.67/11	0.69/11

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1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	4.05/ 6	4.48/ 6	5.39/ 6	6.33/ 6	7.05/ 6	7.50/ 6	7.65/ 6	7.50/ 6	7.05/ 6	6.33/ 6	5.39/ 6	4.48/ 6	4.05/ 6
	7	5.65/ 6	6.14/ 6	7.18/ 6	8.23/ 6	9.05/ 6	9.55/ 6	9.73/ 6	9.55/ 6	9.05/ 6	8.23/ 6	7.18/ 6	6.14/ 6	5.65/ 6
	9	4.75/ 6	5.17/ 6	6.09/ 6	7.03/ 6	7.76/ 6	8.22/ 6	8.38/ 6	8.22/ 6	7.76/ 6	7.03/ 6	6.09/ 6	5.17/ 6	4.75/ 6
	11	3.70/ 6	4.05/ 6	4.81/ 6	5.60/ 6	6.23/ 6	6.63/ 6	6.76/ 6	6.63/ 6	6.23/ 6	5.60/ 6	4.81/ 6	4.05/ 6	3.70/ 6
	13	2.89/ 6	3.16/ 6	3.78/ 6	4.43/ 6	4.96/ 6	5.30/ 6	5.41/ 6	5.30/ 6	4.96/ 6	4.43/ 6	3.78/ 6	3.16/ 6	2.89/ 6
	15	2.28/ 6	2.51/ 6	3.01/ 6	3.55/ 6	3.99/ 6	4.27/ 6	4.37/ 6	4.27/ 6	3.99/ 6	3.55/ 6	3.01/ 6	2.51/ 6	2.28/ 6
	17	1.84/ 6	2.02/ 6	2.44/ 6	2.88/ 6	3.25/ 6	3.49/ 6	3.57/ 6	3.49/ 6	3.25/ 6	2.88/ 6	2.44/ 6	2.02/ 6	1.84/ 6

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.53/ 6	0.58/ 6	0.70/ 6	0.83/ 6	0.95/ 5	1.02/ 5	1.05/ 5	1.02/ 5	0.95/ 5	0.83/ 6	0.70/ 6	0.58/ 6	0.53/ 6
	7	0.99/ 7	1.02/ 7	1.09/ 7	1.18/ 7	1.27/ 7	1.33/ 7	1.35/ 7	1.33/ 7	1.27/ 7	1.18/ 7	1.09/ 7	1.02/ 7	0.99/ 7
	9	1.26/ 9	1.28/ 9	1.32/ 9	1.37/ 9	1.42/ 9	1.46/ 9	1.47/ 9	1.46/ 9	1.42/ 9	1.37/ 9	1.32/ 9	1.28/ 9	1.26/ 9
	11	1.42/11	1.43/11	1.45/11	1.49/11	1.52/11	1.54/11	1.55/11	1.54/11	1.52/11	1.49/11	1.45/11	1.43/11	1.42/11
	13	1.48/13	1.48/13	1.50/13	1.52/13	1.54/13	1.55/13	1.56/13	1.55/13	1.54/13	1.52/13	1.50/13	1.48/13	1.48/13
	15	1.49/16	1.49/16	1.50/16	1.52/16	1.53/16	1.54/16	1.54/16	1.54/16	1.53/16	1.52/16	1.50/16	1.49/16	1.49/16
	17	1.56/16	1.56/16	1.57/16	1.58/16	1.58/16	1.59/16	1.59/16	1.59/16	1.58/16	1.58/16	1.57/16	1.56/16	1.56/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.34/ 6	0.37/ 6	0.45/ 6	0.52/ 6	0.59/ 6	0.63/ 6	0.64/ 6	0.63/ 6	0.59/ 6	0.52/ 6	0.45/ 6	0.37/ 6	0.34/ 6
	7	0.64/ 7	0.70/ 7	0.82/ 6	0.95/ 6	1.07/ 6	1.14/ 6	1.16/ 6	1.14/ 6	1.07/ 6	0.95/ 6	0.82/ 6	0.70/ 7	0.64/ 7
	9	0.71/ 9	0.77/ 9	0.90/ 9	1.05/ 9	1.18/ 9	1.26/ 9	1.29/ 9	1.26/ 9	1.18/ 9	1.05/ 9	0.90/ 9	0.77/ 9	0.71/ 9
	11	0.72/11	0.78/11	0.91/11	1.06/11	1.19/11	1.28/11	1.31/11	1.28/11	1.19/11	1.06/11	0.91/11	0.78/11	0.72/11
	13	0.71/13	0.77/13	0.89/13	1.04/13	1.16/13	1.25/13	1.28/13	1.25/13	1.16/13	1.04/13	0.89/13	0.77/13	0.71/13
	15	0.70/16	0.75/16	0.87/16	1.01/16	1.13/16	1.21/16	1.24/16	1.21/16	1.13/16	1.01/16	0.87/16	0.75/16	0.70/16
	17	0.71/16	0.76/16	0.88/16	1.02/16	1.15/16	1.23/16	1.26/16	1.23/16	1.15/16	1.02/16	0.88/16	0.76/16	0.71/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.10/ 5	0.10/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.09/ 5	0.10/ 5	0.10/ 5
	7	0.11/ 6	0.11/ 6	0.11/ 6	0.10/ 6	0.09/ 6	0.09/ 6	0.09/ 6	0.09/ 6	0.09/ 6	0.10/ 6	0.11/ 6	0.11/ 6	0.11/ 6
	9	0.10/ 7	0.10/ 7	0.10/ 7	0.09/ 7	0.08/ 7	0.07/ 7	0.07/ 7	0.07/ 7	0.08/ 7	0.09/ 7	0.10/ 7	0.10/ 7	0.10/ 7
	11	0.09/ 8	0.09/ 8	0.08/ 8	0.07/ 8	0.07/ 8	0.06/ 8	0.06/ 8	0.06/ 8	0.07/ 8	0.07/ 8	0.08/ 8	0.09/ 8	0.09/ 8
	13	0.07/10	0.07/10	0.07/10	0.06/10	0.05/10	0.05/ 9	0.05/ 9	0.05/ 9	0.05/10	0.06/10	0.07/10	0.07/10	0.07/10
	15	0.06/11	0.06/11	0.06/11	0.05/10	0.04/10	0.04/10	0.04/10	0.04/10	0.04/10	0.05/10	0.06/11	0.06/11	0.06/11
	17	0.05/11	0.05/11	0.05/11	0.04/11	0.04/11	0.03/11	0.03/11	0.03/11	0.04/11	0.04/11	0.05/11	0.05/11	0.05/11

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1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.25/ 6	0.51/ 5	0.78/ 5	0.91/ 5	0.75/ 5	0.00/ 6	0.75/ 5	0.91/ 5	0.78/ 5	0.51/ 5	0.25/ 6	0.00/99
	7	0.00/99	0.35/ 7	0.66/ 7	0.88/ 6	0.90/ 6	0.63/ 6	0.00/ 6	0.63/ 6	0.90/ 6	0.88/ 6	0.66/ 7	0.35/ 7	0.00/99
	9	0.00/99	0.34/ 8	0.62/ 8	0.78/ 7	0.75/ 7	0.49/ 7	0.00/ 6	0.49/ 7	0.75/ 7	0.78/ 7	0.62/ 8	0.34/ 8	0.00/99
	11	0.00/99	0.29/ 9	0.53/ 9	0.65/ 9	0.62/ 8	0.39/ 8	0.00/ 6	0.39/ 8	0.62/ 8	0.65/ 9	0.53/ 9	0.29/ 9	0.00/99
	13	0.00/99	0.25/10	0.45/10	0.54/10	0.50/10	0.31/10	0.00/16	0.31/10	0.50/10	0.54/10	0.45/10	0.25/10	0.00/99
	15	0.00/99	0.21/11	0.38/11	0.45/11	0.42/11	0.26/11	0.00/16	0.26/11	0.42/11	0.45/11	0.38/11	0.21/11	0.00/99
	17	0.00/99	0.18/13	0.32/13	0.38/13	0.35/13	0.21/13	0.00/16	0.21/13	0.35/13	0.38/13	0.32/13	0.18/13	0.00/99

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.17/ 5	1.21/ 5	1.33/ 5	1.50/ 5	1.54/ 5	1.14/ 4	0.00/ 4	1.14/ 4	1.54/ 5	1.50/ 5	1.33/ 5	1.21/ 5	1.17/ 5
	7	1.62/ 7	1.62/ 6	1.61/ 6	1.56/ 6	1.38/ 6	0.89/ 5	0.00/ 7	0.89/ 5	1.38/ 6	1.56/ 6	1.61/ 6	1.62/ 6	1.62/ 7
	9	1.51/ 7	1.50/ 7	1.44/ 7	1.32/ 7	1.09/ 7	0.67/ 6	0.00/ 7	0.67/ 6	1.09/ 7	1.32/ 7	1.44/ 7	1.50/ 7	1.51/ 7
	11	1.30/ 8	1.28/ 8	1.20/ 8	1.07/ 8	0.86/ 8	0.51/ 8	0.00/ 7	0.51/ 8	0.86/ 8	1.07/ 8	1.20/ 8	1.28/ 8	1.30/ 8
	13	1.09/10	1.07/10	1.00/10	0.87/ 9	0.68/ 9	0.40/ 9	0.00/11	0.40/ 9	0.68/ 9	0.87/ 9	1.00/10	1.07/10	1.09/10
	15	0.91/11	0.89/11	0.83/10	0.72/10	0.55/10	0.32/10	0.00/11	0.32/10	0.55/10	0.72/10	0.83/10	0.89/11	0.91/11
	17	0.77/11	0.75/11	0.70/11	0.60/11	0.46/11	0.26/11	0.00/11	0.26/11	0.46/11	0.60/11	0.70/11	0.75/11	0.77/11

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	1.57/ 6	3.27/ 6	5.19/ 6	7.12/ 6	8.66/ 6	9.28/ 6	8.66/ 6	7.12/ 6	5.19/ 6	3.27/ 6	1.57/ 6	0.00/99
	7	0.00/99	2.43/ 6	4.81/ 6	7.17/ 6	9.28/ 6	10.82/ 6	11.41/ 6	10.82/ 6	9.28/ 6	7.17/ 6	4.81/ 6	2.43/ 6	0.00/99
	9	0.00/99	2.02/ 6	4.06/ 6	6.14/ 6	8.01/ 6	9.34/ 6	9.84/ 6	9.34/ 6	8.01/ 6	6.14/ 6	4.06/ 6	2.02/ 6	0.00/99
	11	0.00/99	1.55/ 6	3.16/ 6	4.87/ 6	6.46/ 6	7.59/ 6	8.01/ 6	7.59/ 6	6.46/ 6	4.87/ 6	3.16/ 6	1.55/ 6	0.00/99
	13	0.00/99	1.19/ 6	2.46/ 6	3.84/ 6	5.16/ 6	6.13/ 6	6.48/ 6	6.13/ 6	5.16/ 6	3.84/ 6	2.46/ 6	1.19/ 6	0.00/99
	15	0.00/99	0.94/ 6	1.95/ 6	3.07/ 6	4.16/ 6	4.98/ 6	5.28/ 6	4.98/ 6	4.16/ 6	3.07/ 6	1.95/ 6	0.94/ 6	0.00/99
	17	0.00/99	0.75/ 6	1.57/ 6	2.49/ 6	3.40/ 6	4.09/ 6	4.35/ 6	4.09/ 6	3.40/ 6	2.49/ 6	1.57/ 6	0.75/ 6	0.00/99

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.38/ 6	0.40/ 6	0.45/ 6	0.59/ 6	0.87/ 5	1.25/ 5	1.45/ 5	1.25/ 5	0.87/ 5	0.59/ 6	0.45/ 6	0.40/ 6	0.38/ 6
	7	0.86/ 8	0.89/ 8	0.96/ 7	1.09/ 7	1.28/ 7	1.49/ 7	1.59/ 7	1.49/ 7	1.28/ 7	1.09/ 7	0.96/ 7	0.89/ 8	0.86/ 8
	9	1.18/ 9	1.20/ 9	1.25/ 9	1.33/ 9	1.45/ 9	1.56/ 9	1.61/ 9	1.56/ 9	1.45/ 9	1.33/ 9	1.25/ 9	1.20/ 9	1.18/ 9
	11	1.37/11	1.38/11	1.41/11	1.47/11	1.54/11	1.60/11	1.63/11	1.60/11	1.54/11	1.47/11	1.41/11	1.38/11	1.37/11
	13	1.44/13	1.45/13	1.47/13	1.51/13	1.55/13	1.59/13	1.61/13	1.59/13	1.55/13	1.51/13	1.47/13	1.45/13	1.44/13
	15	1.46/16	1.47/16	1.49/16	1.51/16	1.54/16	1.57/16	1.58/16	1.57/16	1.54/16	1.51/16	1.49/16	1.47/16	1.46/16
	17	1.54/16	1.54/16	1.56/16	1.57/16	1.59/16	1.61/16	1.62/16	1.61/16	1.59/16	1.57/16	1.56/16	1.54/16	1.54/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.14/ 6	0.29/ 6	0.44/ 6	0.59/ 6	0.73/ 6	0.82/ 6	0.73/ 6	0.59/ 6	0.44/ 6	0.29/ 6	0.14/ 6	0.00/99
	7	0.00/99	0.29/ 7	0.57/ 7	0.86/ 7	1.12/ 6	1.31/ 6	1.39/ 6	1.31/ 6	1.12/ 6	0.86/ 7	0.57/ 7	0.29/ 7	0.00/99
	9	0.00/99	0.33/ 9	0.66/ 9	0.98/ 9	1.26/ 9	1.46/ 9	1.53/ 9	1.46/ 9	1.26/ 9	0.98/ 9	0.66/ 9	0.33/ 9	0.00/99
	11	0.00/99	0.35/11	0.69/11	1.01/11	1.29/11	1.47/11	1.54/11	1.47/11	1.29/11	1.01/11	0.69/11	0.35/11	0.00/99
	13	0.00/99	0.35/13	0.69/13	1.00/13	1.26/13	1.44/13	1.50/13	1.44/13	1.26/13	1.00/13	0.69/13	0.35/13	0.00/99
	15	0.00/99	0.35/16	0.68/16	0.98/16	1.23/16	1.39/16	1.45/16	1.39/16	1.23/16	0.98/16	0.68/16	0.35/16	0.00/99
	17	0.00/99	0.36/16	0.70/16	1.01/16	1.25/16	1.41/16	1.47/16	1.41/16	1.25/16	1.01/16	0.70/16	0.36/16	0.00/99

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.09/ 5	0.09/ 5	0.10/ 5	0.11/ 5	0.11/ 5	0.08/ 4	0.00/ 4	0.08/ 4	0.11/ 5	0.11/ 5	0.10/ 5	0.09/ 5	0.09/ 5
	7	0.12/ 7	0.12/ 6	0.12/ 6	0.11/ 6	0.10/ 6	0.07/ 5	0.00/ 7	0.07/ 5	0.10/ 6	0.11/ 6	0.12/ 6	0.12/ 6	0.12/ 7
	9	0.11/ 7	0.11/ 7	0.10/ 7	0.10/ 7	0.08/ 7	0.05/ 6	0.00/ 7	0.05/ 6	0.08/ 7	0.10/ 7	0.10/ 7	0.11/ 7	0.11/ 7
	11	0.09/ 8	0.09/ 8	0.09/ 8	0.08/ 8	0.06/ 8	0.04/ 8	0.00/ 7	0.04/ 8	0.06/ 8	0.08/ 8	0.09/ 8	0.09/ 8	0.09/ 8
	13	0.08/10	0.08/10	0.07/10	0.06/ 9	0.05/ 9	0.03/ 9	0.00/11	0.03/ 9	0.05/ 9	0.06/ 9	0.07/10	0.08/10	0.08/10
	15	0.07/11	0.07/11	0.06/10	0.05/10	0.04/10	0.02/10	0.00/11	0.02/10	0.04/10	0.05/10	0.06/10	0.07/11	0.07/11
	17	0.06/13	0.06/13	0.05/11	0.04/11	0.03/11	0.02/11	0.00/11	0.02/11	0.03/11	0.04/11	0.05/11	0.06/13	0.06/13

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.54/ 5	0.56/ 5	0.60/ 5	0.65/ 5	0.70/ 5	0.73/ 5	0.75/ 5	0.73/ 5	0.70/ 5	0.65/ 5	0.60/ 5	0.56/ 5	0.54/ 5
	7	0.62/ 6	0.63/ 6	0.65/ 6	0.68/ 6	0.71/ 6	0.72/ 6	0.73/ 6	0.72/ 6	0.71/ 6	0.68/ 6	0.65/ 6	0.63/ 6	0.62/ 6
	9	0.56/ 8	0.56/ 8	0.57/ 8	0.59/ 8	0.61/ 8	0.62/ 8	0.62/ 8	0.62/ 8	0.61/ 8	0.59/ 8	0.57/ 8	0.56/ 8	0.56/ 8
	11	0.46/ 8	0.46/ 8	0.47/ 8	0.48/ 8	0.49/ 8	0.50/ 8	0.50/ 8	0.50/ 8	0.49/ 8	0.48/ 8	0.47/ 8	0.46/ 8	0.46/ 8
	13	0.38/10	0.38/10	0.39/10	0.40/10	0.40/10	0.41/10	0.41/10	0.41/10	0.40/10	0.40/10	0.39/10	0.38/10	0.38/10
	15	0.33/10	0.33/10	0.33/10	0.34/10	0.34/10	0.35/10	0.35/10	0.35/10	0.34/10	0.34/10	0.33/10	0.33/10	0.33/10
	17	0.28/10	0.28/10	0.29/10	0.29/10	0.29/10	0.30/10	0.30/10	0.30/10	0.29/10	0.29/10	0.29/10	0.28/10	0.28/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.31/ 5	1.31/ 5	1.29/ 5	1.27/ 5	1.25/ 5	1.24/ 5	1.23/ 5	1.24/ 5	1.25/ 5	1.27/ 5	1.29/ 5	1.31/ 5	1.31/ 5
	7	1.55/ 6	1.53/ 6	1.47/ 6	1.37/ 6	1.27/ 6	1.20/ 6	1.17/ 6	1.20/ 6	1.27/ 6	1.37/ 6	1.47/ 6	1.53/ 6	1.55/ 6
	9	1.40/ 8	1.37/ 8	1.30/ 8	1.20/ 8	1.09/ 8	1.00/ 8	0.96/ 6	1.00/ 8	1.09/ 8	1.20/ 8	1.30/ 8	1.37/ 8	1.40/ 8
	11	1.15/ 8	1.12/ 8	1.06/ 8	0.97/ 8	0.87/ 8	0.79/ 8	0.76/ 8	0.79/ 8	0.87/ 8	0.97/ 8	1.06/ 8	1.12/ 8	1.15/ 8
	13	0.94/10	0.92/10	0.87/10	0.79/10	0.71/10	0.64/10	0.61/10	0.64/10	0.71/10	0.79/10	0.87/10	0.92/10	0.94/10
	15	0.80/10	0.79/10	0.74/10	0.67/10	0.60/10	0.53/10	0.51/10	0.53/10	0.60/10	0.67/10	0.74/10	0.79/10	0.80/10
	17	0.69/10	0.68/10	0.63/10	0.57/10	0.51/10	0.45/10	0.43/10	0.45/10	0.51/10	0.57/10	0.63/10	0.68/10	0.69/10

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	3.51/ 5	3.99/ 5	4.95/ 5	5.87/ 5	6.57/ 5	6.99/ 5	7.14/ 5	6.99/ 5	6.57/ 5	5.87/ 5	4.95/ 5	3.99/ 5	3.51/ 5
	7	3.61/ 6	4.06/ 6	4.99/ 6	5.90/ 6	6.59/ 6	7.02/ 6	7.17/ 6	7.02/ 6	6.59/ 6	5.90/ 6	4.99/ 6	4.06/ 6	3.61/ 6
	9	2.83/ 6	3.18/ 6	3.92/ 6	4.66/ 6	5.25/ 6	5.62/ 6	5.74/ 6	5.62/ 6	5.25/ 6	4.66/ 6	3.92/ 6	3.18/ 6	2.83/ 6
	11	2.15/ 6	2.42/ 6	2.99/ 6	3.58/ 6	4.05/ 6	4.34/ 6	4.44/ 6	4.34/ 6	4.05/ 6	3.58/ 6	2.99/ 6	2.42/ 6	2.15/ 6
	13	1.67/ 6	1.88/ 6	2.33/ 6	2.79/ 6	3.17/ 6	3.40/ 6	3.48/ 6	3.40/ 6	3.17/ 6	2.79/ 6	2.33/ 6	1.88/ 6	1.67/ 6
	15	1.33/ 6	1.50/ 6	1.86/ 6	2.24/ 6	2.54/ 6	2.73/ 6	2.80/ 6	2.73/ 6	2.54/ 6	2.24/ 6	1.86/ 6	1.50/ 6	1.33/ 6
	17	1.08/ 6	1.22/ 6	1.52/ 6	1.83/ 6	2.08/ 6	2.24/ 6	2.29/ 6	2.24/ 6	2.08/ 6	1.83/ 6	1.52/ 6	1.22/ 6	1.08/ 6

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.51/ 6	0.56/ 6	0.68/ 6	0.81/ 6	0.93/ 5	1.00/ 5	1.03/ 5	1.00/ 5	0.93/ 5	0.81/ 6	0.68/ 6	0.56/ 6	0.51/ 6
	7	1.00/ 8	1.03/ 8	1.10/ 8	1.18/ 8	1.27/ 8	1.32/ 8	1.34/ 8	1.32/ 8	1.27/ 8	1.18/ 8	1.10/ 8	1.03/ 8	1.00/ 8
	9	1.22/10	1.23/10	1.27/10	1.33/10	1.38/ 8	1.42/ 8	1.43/ 8	1.42/ 8	1.38/ 8	1.33/10	1.27/10	1.23/10	1.22/10
	11	1.26/10	1.26/10	1.29/10	1.32/10	1.36/10	1.38/10	1.39/10	1.38/10	1.36/10	1.32/10	1.29/10	1.26/10	1.26/10
	13	1.49/10	1.49/10	1.51/10	1.53/10	1.54/10	1.56/10	1.56/10	1.56/10	1.54/10	1.53/10	1.51/10	1.49/10	1.49/10
	15	1.68/16	1.69/16	1.70/16	1.71/16	1.72/16	1.73/16	1.73/16	1.73/16	1.72/16	1.71/16	1.70/16	1.69/16	1.68/16
	17	1.68/16	1.68/16	1.69/16	1.70/16	1.70/16	1.71/16	1.71/16	1.71/16	1.70/16	1.70/16	1.69/16	1.68/16	1.68/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.35/ 6	0.39/ 6	0.49/ 6	0.59/ 6	0.67/ 6	0.72/ 6	0.74/ 6	0.72/ 6	0.67/ 6	0.59/ 6	0.49/ 6	0.39/ 6	0.35/ 6
	7	0.58/ 8	0.64/ 8	0.77/ 6	0.92/ 6	1.04/ 6	1.12/ 6	1.15/ 6	1.12/ 6	1.04/ 6	0.92/ 6	0.77/ 6	0.64/ 8	0.58/ 8
	9	0.64/ 8	0.70/ 8	0.83/ 8	0.98/ 8	1.11/ 8	1.19/ 8	1.22/ 8	1.19/ 8	1.11/ 8	0.98/ 8	0.83/ 8	0.70/ 8	0.64/ 8
	11	0.63/10	0.68/10	0.80/10	0.94/10	1.06/10	1.14/10	1.17/10	1.14/10	1.06/10	0.94/10	0.80/10	0.68/10	0.63/10
	13	0.71/10	0.76/10	0.89/10	1.04/10	1.16/10	1.25/10	1.28/10	1.25/10	1.16/10	1.04/10	0.89/10	0.76/10	0.71/10
	15	0.79/16	0.85/16	0.98/16	1.14/16	1.28/16	1.37/16	1.40/16	1.37/16	1.28/16	1.14/16	0.98/16	0.85/16	0.79/16
	17	0.78/16	0.84/16	0.97/16	1.12/16	1.26/16	1.35/16	1.38/16	1.35/16	1.26/16	1.12/16	0.97/16	0.84/16	0.78/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.11/ 5	0.11/ 5	0.10/ 5	0.10/ 5	0.10/ 5	0.10/ 5	0.10/ 5	0.10/ 5	0.10/ 5	0.10/ 5	0.10/ 5	0.11/ 5	0.11/ 5
	7	0.13/ 6	0.12/ 6	0.12/ 6	0.11/ 6	0.10/ 6	0.10/ 6	0.09/ 6	0.10/ 6	0.10/ 6	0.11/ 6	0.12/ 6	0.12/ 6	0.13/ 6
	9	0.11/ 8	0.11/ 8	0.11/ 8	0.10/ 8	0.09/ 8	0.08/ 8	0.08/ 8	0.08/ 8	0.09/ 8	0.10/ 8	0.11/ 8	0.11/ 8	0.11/ 8
	11	0.09/ 8	0.09/ 8	0.09/ 8	0.08/ 8	0.07/ 8	0.06/ 8	0.06/ 8	0.06/ 8	0.07/ 8	0.08/ 8	0.09/ 8	0.09/ 8	0.09/ 8
	13	0.08/10	0.08/10	0.07/10	0.06/10	0.06/10	0.05/10	0.05/10	0.05/10	0.06/10	0.06/10	0.07/10	0.08/10	0.08/10
	15	0.07/10	0.06/10	0.06/10	0.06/10	0.05/10	0.04/10	0.04/10	0.04/10	0.05/10	0.06/10	0.06/10	0.06/10	0.07/10
	17	0.06/10	0.06/10	0.05/10	0.05/10	0.04/10	0.04/10	0.04/10	0.04/10	0.04/10	0.05/10	0.05/10	0.06/10	0.06/10

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.27/ 6	0.54/ 5	0.81/ 5	0.96/ 5	0.78/ 4	0.00/ 6	0.78/ 4	0.96/ 5	0.81/ 5	0.54/ 5	0.27/ 6	0.00/99
	7	0.00/99	0.37/ 6	0.69/ 6	0.91/ 6	0.94/ 6	0.65/ 6	0.00/ 8	0.65/ 6	0.94/ 6	0.91/ 6	0.69/ 6	0.37/ 6	0.00/99
	9	0.00/99	0.35/ 8	0.65/ 8	0.81/ 8	0.79/ 8	0.52/ 8	0.00/ 8	0.52/ 8	0.79/ 8	0.81/ 8	0.65/ 8	0.35/ 8	0.00/99
	11	0.00/99	0.30/ 8	0.54/ 8	0.67/ 8	0.63/ 8	0.40/ 8	0.00/10	0.40/ 8	0.63/ 8	0.67/ 8	0.54/ 8	0.30/ 8	0.00/99
	13	0.00/99	0.25/10	0.45/10	0.55/10	0.51/10	0.32/10	0.00/10	0.32/10	0.51/10	0.55/10	0.45/10	0.25/10	0.00/99
	15	0.00/99	0.22/10	0.39/10	0.47/10	0.43/10	0.27/10	0.00/16	0.27/10	0.43/10	0.47/10	0.39/10	0.22/10	0.00/99
	17	0.00/99	0.19/10	0.34/10	0.41/10	0.37/10	0.23/10	0.00/16	0.23/10	0.37/10	0.41/10	0.34/10	0.19/10	0.00/99

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.19/ 5	1.22/ 5	1.32/ 5	1.47/ 5	1.53/ 4	1.13/ 4	0.00/ 4	1.13/ 4	1.53/ 4	1.47/ 5	1.32/ 5	1.22/ 5	1.19/ 5
	7	1.60/ 6	1.60/ 6	1.59/ 6	1.53/ 6	1.36/ 6	0.88/ 5	0.00/ 4	0.88/ 5	1.36/ 6	1.53/ 6	1.59/ 6	1.60/ 6	1.60/ 6
	9	1.50/ 8	1.48/ 8	1.42/ 8	1.30/ 8	1.08/ 6	0.66/ 6	0.00/ 8	0.66/ 6	1.08/ 6	1.30/ 8	1.42/ 8	1.48/ 8	1.50/ 8
	11	1.25/ 8	1.23/ 8	1.16/ 8	1.04/ 8	0.83/ 8	0.49/ 8	0.00/10	0.49/ 8	0.83/ 8	1.04/ 8	1.16/ 8	1.23/ 8	1.25/ 8
	13	1.04/10	1.02/10	0.96/10	0.84/10	0.66/ 8	0.38/ 8	0.00/10	0.38/ 8	0.66/ 8	0.84/10	0.96/10	1.02/10	1.04/10
	15	0.89/10	0.87/10	0.81/10	0.70/10	0.54/10	0.31/10	0.00/16	0.31/10	0.54/10	0.70/10	0.81/10	0.87/10	0.89/10
	17	0.77/10	0.75/10	0.70/10	0.60/10	0.46/10	0.26/10	0.00/16	0.26/10	0.46/10	0.60/10	0.70/10	0.75/10	0.77/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.98/ 6	2.33/ 6	4.21/ 5	6.36/ 5	8.13/ 5	8.85/ 5	8.13/ 5	6.36/ 5	4.21/ 5	2.33/ 6	0.98/ 6	0.00/99
	7	0.00/99	1.13/ 6	2.57/ 6	4.48/ 6	6.54/ 6	8.15/ 6	8.77/ 5	8.15/ 6	6.54/ 6	4.48/ 6	2.57/ 6	1.13/ 6	0.00/99
	9	0.00/99	0.92/ 6	2.08/ 6	3.59/ 6	5.25/ 6	6.58/ 6	7.09/ 6	6.58/ 6	5.25/ 6	3.59/ 6	2.08/ 6	0.92/ 6	0.00/99
	11	0.00/99	0.71/ 6	1.60/ 6	2.76/ 6	4.06/ 6	5.13/ 6	5.55/ 6	5.13/ 6	4.06/ 6	2.76/ 6	1.60/ 6	0.71/ 6	0.00/99
	13	0.00/99	0.56/ 8	1.25/ 6	2.15/ 6	3.18/ 6	4.04/ 6	4.38/ 6	4.04/ 6	3.18/ 6	2.15/ 6	1.25/ 6	0.56/ 8	0.00/99
	15	0.00/99	0.45/ 8	1.00/ 6	1.73/ 6	2.55/ 6	3.25/ 6	3.53/ 6	3.25/ 6	2.55/ 6	1.73/ 6	1.00/ 6	0.45/ 8	0.00/99
	17	0.00/99	0.37/10	0.82/ 6	1.41/ 6	2.09/ 6	2.67/ 6	2.90/ 6	2.67/ 6	2.09/ 6	1.41/ 6	0.82/ 6	0.37/10	0.00/99

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.34/ 6	0.36/ 6	0.43/ 6	0.58/ 6	0.86/ 5	1.22/ 5	1.42/ 5	1.22/ 5	0.86/ 5	0.58/ 6	0.43/ 6	0.36/ 6	0.34/ 6
	7	0.88/ 8	0.90/ 8	0.97/ 8	1.10/ 8	1.28/ 8	1.48/ 6	1.58/ 6	1.48/ 6	1.28/ 8	1.10/ 8	0.97/ 8	0.90/ 8	0.88/ 8
	9	1.13/10	1.15/10	1.21/10	1.29/10	1.40/ 8	1.52/ 8	1.57/ 8	1.52/ 8	1.40/ 8	1.29/10	1.21/10	1.15/10	1.13/10
	11	1.20/10	1.21/10	1.25/10	1.31/10	1.38/10	1.45/10	1.48/10	1.45/10	1.38/10	1.31/10	1.25/10	1.21/10	1.20/10
	13	1.46/10	1.46/10	1.48/10	1.52/10	1.56/10	1.59/10	1.61/10	1.59/10	1.56/10	1.52/10	1.48/10	1.46/10	1.46/10
	15	1.66/16	1.67/16	1.68/16	1.70/16	1.73/16	1.75/16	1.76/16	1.75/16	1.73/16	1.70/16	1.68/16	1.67/16	1.66/16
	17	1.66/16	1.67/16	1.68/16	1.69/16	1.71/16	1.73/16	1.73/16	1.73/16	1.71/16	1.69/16	1.68/16	1.67/16	1.66/16

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.11/ 6	0.26/ 6	0.45/ 6	0.67/ 6	0.86/ 6	0.96/ 6	0.86/ 6	0.67/ 6	0.45/ 6	0.26/ 6	0.11/ 6	0.00/99
	7	0.00/99	0.24/ 8	0.50/ 8	0.80/ 8	1.09/ 6	1.32/ 6	1.41/ 6	1.32/ 6	1.09/ 6	0.80/ 8	0.50/ 8	0.24/ 8	0.00/99
	9	0.00/99	0.29/10	0.59/10	0.89/ 8	1.18/ 8	1.39/ 8	1.47/ 8	1.39/ 8	1.18/ 8	0.89/ 8	0.59/10	0.29/10	0.00/99
	11	0.00/99	0.30/10	0.59/10	0.88/10	1.14/10	1.32/10	1.39/10	1.32/10	1.14/10	0.88/10	0.59/10	0.30/10	0.00/99
	13	0.00/99	0.35/10	0.69/10	1.00/10	1.26/10	1.44/10	1.51/10	1.44/10	1.26/10	1.00/10	0.69/10	0.35/10	0.00/99
	15	0.00/99	0.40/16	0.78/16	1.12/16	1.39/16	1.57/16	1.64/16	1.57/16	1.39/16	1.12/16	0.78/16	0.40/16	0.00/99
	17	0.00/99	0.40/16	0.77/16	1.11/16	1.37/16	1.55/16	1.61/16	1.55/16	1.37/16	1.11/16	0.77/16	0.40/16	0.00/99

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

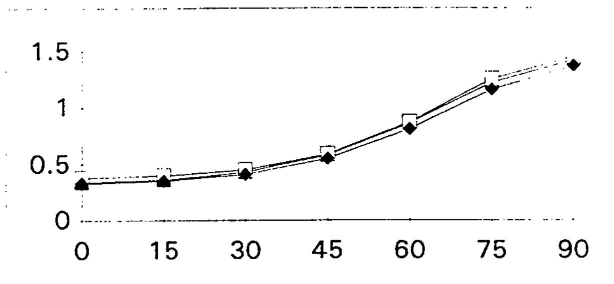
V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.10/ 5	0.10/ 5	0.11/ 5	0.12/ 5	0.12/ 4	0.09/ 4	0.00/ 4	0.09/ 4	0.12/ 4	0.12/ 5	0.11/ 5	0.10/ 5	0.10/ 5
	7	0.13/ 6	0.13/ 6	0.13/ 6	0.12/ 6	0.11/ 6	0.07/ 5	0.00/ 4	0.07/ 5	0.11/ 6	0.12/ 6	0.13/ 6	0.13/ 6	0.13/ 6
	9	0.12/ 8	0.12/ 8	0.12/ 8	0.11/ 8	0.09/ 6	0.05/ 6	0.00/ 8	0.05/ 6	0.09/ 6	0.11/ 8	0.12/ 8	0.12/ 8	0.12/ 8
	11	0.10/ 8	0.10/ 8	0.09/ 8	0.08/ 8	0.07/ 8	0.04/ 8	0.00/10	0.04/ 8	0.07/ 8	0.08/ 8	0.09/ 8	0.10/ 8	0.10/ 8
	13	0.09/10	0.08/10	0.08/10	0.07/10	0.05/10	0.03/ 8	0.00/10	0.03/ 8	0.05/10	0.07/10	0.08/10	0.08/10	0.09/10
	15	0.07/10	0.07/10	0.07/10	0.06/10	0.04/10	0.03/10	0.00/16	0.03/10	0.04/10	0.06/10	0.07/10	0.07/10	0.07/10
	17	0.06/10	0.06/10	0.06/10	0.05/10	0.04/10	0.02/10	0.00/16	0.02/10	0.04/10	0.05/10	0.06/10	0.06/10	0.06/10

Amphibious Cargo Beaching Lighter Development

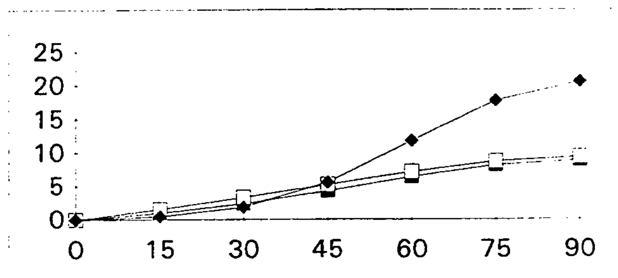
Basic Motions Analysis

3 x 40 foot modules loaded (290 LT) displacement
3 foot significant wave height, modal period 5 sec

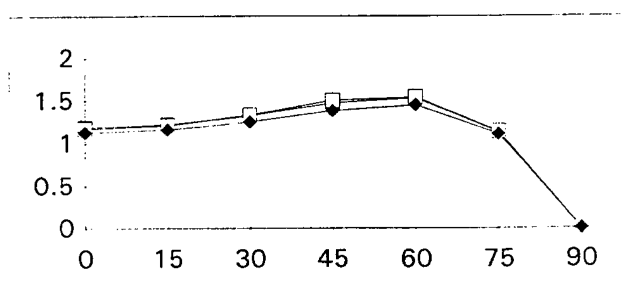
Heave	B2	C2	D2
0	0.34	0.38	0.33
15	0.36	0.4	0.35
30	0.43	0.45	0.41
45	0.58	0.59	0.55
60	0.86	0.87	0.81
75	1.22	1.25	1.16
90	1.42	1.45	1.37



Roll	B2	C2	D2
0	0	0	0
15	0.98	1.57	0.49
30	2.33	3.27	1.83
45	4.21	5.19	5.51
60	6.36	7.12	11.73
75	8.13	8.66	17.76
90	8.85	9.28	20.55



Pitch	B2	C2	D2
0	1.19	1.17	1.13
15	1.22	1.21	1.16
30	1.32	1.33	1.25
45	1.47	1.5	1.38
60	1.53	1.54	1.45
75	1.13	1.14	1.11
90	0	0	0



Model B2	basic rectangular hull
Model C2	hull with 10 deg flare
Model D2	hull with 10 deg deadrise angle

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.41/ 5	0.43/ 5	0.46/ 5	0.50/ 5	0.54/ 5	0.57/ 5	0.58/ 5	0.57/ 5	0.54/ 5	0.50/ 5	0.46/ 5	0.43/ 5	0.41/ 5
	7	0.50/ 6	0.51/ 6	0.53/ 6	0.55/ 6	0.57/ 6	0.59/ 6	0.59/ 6	0.59/ 6	0.57/ 6	0.55/ 6	0.53/ 6	0.51/ 6	0.50/ 6
	9	0.47/ 8	0.47/ 8	0.48/ 8	0.50/ 8	0.51/ 8	0.52/ 8	0.52/ 8	0.52/ 8	0.51/ 8	0.50/ 8	0.48/ 8	0.47/ 8	0.47/ 8
	11	0.39/ 8	0.40/ 8	0.40/ 8	0.41/ 8	0.42/ 8	0.42/ 8	0.43/ 8	0.42/ 8	0.42/ 8	0.41/ 8	0.40/ 8	0.40/ 8	0.39/ 8
	13	0.33/10	0.33/10	0.34/10	0.34/10	0.35/10	0.35/10	0.35/10	0.35/10	0.35/10	0.34/10	0.34/10	0.33/10	0.33/10
	15	0.29/10	0.29/10	0.29/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.29/10	0.29/10	0.29/10
	17	0.25/10	0.25/10	0.26/10	0.26/10	0.26/10	0.26/10	0.26/10	0.26/10	0.26/10	0.26/10	0.26/10	0.25/10	0.25/10

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED

SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE

(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.20/ 5	1.19/ 5	1.18/ 5	1.15/ 5	1.13/ 5	1.11/ 5	1.10/ 5	1.11/ 5	1.13/ 5	1.15/ 5	1.18/ 5	1.19/ 5	1.20/ 5
	7	1.43/ 6	1.41/ 6	1.35/ 6	1.26/ 6	1.16/ 6	1.09/ 6	1.06/ 6	1.09/ 6	1.16/ 6	1.26/ 6	1.35/ 6	1.41/ 6	1.43/ 6
	9	1.30/ 8	1.27/ 8	1.21/ 8	1.11/ 8	1.00/ 8	0.92/ 8	0.88/ 8	0.92/ 8	1.00/ 8	1.11/ 8	1.21/ 8	1.27/ 8	1.30/ 8
	11	1.07/ 8	1.05/ 8	0.99/ 8	0.90/ 8	0.81/ 8	0.73/ 8	0.70/ 8	0.73/ 8	0.81/ 8	0.90/ 8	0.99/ 8	1.05/ 8	1.07/ 8
	13	0.88/10	0.86/10	0.81/10	0.74/10	0.66/10	0.59/10	0.56/10	0.59/10	0.66/10	0.74/10	0.81/10	0.86/10	0.88/10
	15	0.75/10	0.73/10	0.69/10	0.63/10	0.55/10	0.50/10	0.47/10	0.50/10	0.55/10	0.63/10	0.69/10	0.73/10	0.75/10
	17	0.64/10	0.63/10	0.59/10	0.54/10	0.47/10	0.42/10	0.40/10	0.42/10	0.47/10	0.54/10	0.59/10	0.63/10	0.64/10

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED

SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.16/ 5	1.54/ 5	2.29/ 4	3.03/ 4	3.62/ 4	3.99/ 4	4.12/ 4	3.99/ 4	3.62/ 4	3.03/ 4	2.29/ 4	1.54/ 5	1.16/ 5
	7	1.09/ 6	1.32/ 6	1.80/ 6	2.29/ 6	2.70/ 5	2.97/ 5	3.06/ 5	2.97/ 5	2.70/ 5	2.29/ 6	1.80/ 6	1.32/ 6	1.09/ 6
	9	0.91/ 8	1.06/ 8	1.38/ 6	1.72/ 6	2.01/ 6	2.19/ 6	2.26/ 6	2.19/ 6	2.01/ 6	1.72/ 6	1.38/ 6	1.06/ 8	0.91/ 8
	11	0.73/ 8	0.83/ 8	1.05/ 8	1.30/ 8	1.51/ 8	1.64/ 8	1.69/ 8	1.64/ 8	1.51/ 8	1.30/ 8	1.05/ 8	0.83/ 8	0.73/ 8
	13	0.59/10	0.66/10	0.83/ 8	1.02/ 8	1.17/ 8	1.28/ 8	1.31/ 8	1.28/ 8	1.17/ 8	1.02/ 8	0.83/ 8	0.66/10	0.59/10
	15	0.50/10	0.55/10	0.68/10	0.83/10	0.95/10	1.03/10	1.06/10	1.03/10	0.95/10	0.83/10	0.68/10	0.55/10	0.50/10
	17	0.42/10	0.47/10	0.57/10	0.69/10	0.79/10	0.86/10	0.88/10	0.86/10	0.79/10	0.69/10	0.57/10	0.47/10	0.42/10

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.46/ 6	0.50/ 6	0.60/ 6	0.71/ 6	0.81/ 6	0.87/ 5	0.90/ 5	0.87/ 5	0.81/ 6	0.71/ 6	0.60/ 6	0.50/ 6	0.46/ 6
	7	0.93/ 8	0.95/ 8	1.01/ 8	1.09/ 8	1.16/ 8	1.21/ 8	1.22/ 8	1.21/ 8	1.16/ 8	1.09/ 8	1.01/ 8	0.95/ 8	0.93/ 8
	9	1.14/10	1.16/10	1.19/10	1.24/10	1.29/ 8	1.32/ 8	1.33/ 8	1.32/ 8	1.29/ 8	1.24/10	1.19/10	1.16/10	1.14/10
	11	1.19/10	1.19/10	1.22/10	1.25/10	1.28/10	1.30/10	1.31/10	1.30/10	1.28/10	1.25/10	1.22/10	1.19/10	1.19/10
	13	1.41/10	1.42/10	1.43/10	1.45/10	1.47/10	1.48/10	1.48/10	1.48/10	1.47/10	1.45/10	1.43/10	1.42/10	1.41/10
	15	1.61/16	1.61/16	1.62/16	1.63/16	1.64/16	1.65/16	1.65/16	1.65/16	1.64/16	1.63/16	1.62/16	1.61/16	1.61/16
	17	1.60/16	1.61/16	1.61/16	1.62/16	1.63/16	1.63/16	1.64/16	1.63/16	1.63/16	1.62/16	1.61/16	1.61/16	1.60/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.29/ 6	0.35/ 6	0.49/ 5	0.62/ 5	0.74/ 5	0.81/ 5	0.83/ 5	0.81/ 5	0.74/ 5	0.62/ 5	0.49/ 5	0.35/ 6	0.29/ 6
	7	0.47/ 8	0.52/ 8	0.65/ 8	0.78/ 8	0.90/ 8	0.98/ 8	1.01/ 8	0.98/ 8	0.90/ 8	0.78/ 8	0.65/ 8	0.52/ 8	0.47/ 8
	9	0.54/10	0.59/10	0.70/ 8	0.83/ 8	0.95/ 8	1.02/ 8	1.05/ 8	1.02/ 8	0.95/ 8	0.83/ 8	0.70/ 8	0.59/10	0.54/10
	11	0.54/10	0.58/10	0.69/10	0.81/10	0.91/10	0.98/10	1.01/10	0.98/10	0.91/10	0.81/10	0.69/10	0.58/10	0.54/10
	13	0.63/10	0.67/10	0.78/10	0.91/10	1.02/10	1.10/10	1.12/10	1.10/10	1.02/10	0.91/10	0.78/10	0.67/10	0.63/10
	15	0.70/16	0.75/16	0.87/16	1.01/16	1.13/16	1.21/16	1.24/16	1.21/16	1.13/16	1.01/16	0.87/16	0.75/16	0.70/16
	17	0.70/16	0.75/16	0.86/16	1.00/16	1.12/16	1.20/16	1.23/16	1.20/16	1.12/16	1.00/16	0.86/16	0.75/16	0.70/16

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.05/ 5	0.05/ 5	0.05/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5
	7	0.07/ 6	0.07/ 6	0.07/ 6	0.06/ 6	0.06/ 6	0.05/ 6	0.05/ 6	0.05/ 6	0.06/ 6	0.06/ 6	0.07/ 6	0.07/ 6	0.07/ 6
	9	0.06/ 8	0.06/ 8	0.06/ 8	0.05/ 8	0.05/ 8	0.05/ 8	0.04/ 8	0.05/ 8	0.05/ 8	0.05/ 8	0.06/ 8	0.06/ 8	0.06/ 8
	11	0.05/ 8	0.05/ 8	0.05/ 8	0.04/ 8	0.04/ 8	0.04/ 8	0.03/ 8	0.04/ 8	0.04/ 8	0.04/ 8	0.05/ 8	0.05/ 8	0.05/ 8
	13	0.04/10	0.04/10	0.04/10	0.04/10	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10	0.04/10	0.04/10	0.04/10	0.04/10
	15	0.04/10	0.04/10	0.03/10	0.03/10	0.03/10	0.02/10	0.02/10	0.02/10	0.03/10	0.03/10	0.03/10	0.04/10	0.04/10
	17	0.03/10	0.03/10	0.03/10	0.03/10	0.02/10	0.02/10	0.02/10	0.02/10	0.02/10	0.03/10	0.03/10	0.03/10	0.03/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.20/ 6	0.41/ 6	0.61/ 5	0.73/ 5	0.63/ 5	0.00/ 5	0.63/ 5	0.73/ 5	0.61/ 5	0.41/ 6	0.20/ 6	0.00/99
	7	0.00/99	0.30/ 6	0.57/ 6	0.74/ 6	0.75/ 6	0.53/ 6	0.00/ 8	0.53/ 6	0.75/ 6	0.74/ 6	0.57/ 6	0.30/ 6	0.00/99
	9	0.00/99	0.30/ 8	0.55/ 8	0.68/ 8	0.66/ 8	0.43/ 8	0.00/ 8	0.43/ 8	0.66/ 8	0.68/ 8	0.55/ 8	0.30/ 8	0.00/99
	11	0.00/99	0.26/ 8	0.47/ 8	0.57/ 8	0.54/ 8	0.34/ 8	0.00/10	0.34/ 8	0.54/ 8	0.57/ 8	0.47/ 8	0.26/ 8	0.00/99
	13	0.00/99	0.22/10	0.40/10	0.48/10	0.44/10	0.28/10	0.00/10	0.28/10	0.44/10	0.48/10	0.40/10	0.22/10	0.00/99
	15	0.00/99	0.20/10	0.35/10	0.42/10	0.38/10	0.23/10	0.00/16	0.23/10	0.38/10	0.42/10	0.35/10	0.20/10	0.00/99
	17	0.00/99	0.17/10	0.30/10	0.36/10	0.33/10	0.20/10	0.00/16	0.20/10	0.33/10	0.36/10	0.30/10	0.17/10	0.00/99

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED

SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE

(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.11/ 5	1.14/ 5	1.22/ 5	1.32/ 5	1.34/ 5	1.02/ 4	0.00/ 5	1.02/ 4	1.34/ 5	1.32/ 5	1.22/ 5	1.14/ 5	1.11/ 5
	7	1.49/ 6	1.49/ 6	1.47/ 6	1.40/ 6	1.22/ 6	0.79/ 5	0.00/ 6	0.79/ 5	1.22/ 6	1.40/ 6	1.47/ 6	1.49/ 6	1.49/ 6
	9	1.40/ 8	1.38/ 8	1.32/ 8	1.20/ 8	0.98/ 6	0.60/ 6	0.00/10	0.60/ 6	0.98/ 6	1.20/ 8	1.32/ 8	1.38/ 8	1.40/ 8
	11	1.17/ 8	1.15/ 8	1.08/ 8	0.96/ 8	0.76/ 8	0.45/ 8	0.00/10	0.45/ 8	0.76/ 8	0.96/ 8	1.08/ 8	1.15/ 8	1.17/ 8
	13	0.97/10	0.95/10	0.89/10	0.78/10	0.61/ 8	0.35/ 8	0.00/10	0.35/ 8	0.61/ 8	0.78/10	0.89/10	0.95/10	0.97/10
	15	0.84/10	0.82/10	0.76/10	0.66/10	0.50/10	0.29/10	0.00/16	0.29/10	0.50/10	0.66/10	0.76/10	0.82/10	0.84/10
	17	0.72/10	0.71/10	0.65/10	0.56/10	0.42/10	0.24/10	0.00/16	0.24/10	0.42/10	0.56/10	0.65/10	0.71/10	0.72/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.33/ 4	0.70/ 4	1.24/ 5	2.30/ 5	4.67/ 4	7.19/ 4	4.67/ 4	2.30/ 5	1.24/ 5	0.70/ 4	0.33/ 4	0.00/99
	7	0.00/99	0.37/ 6	0.79/ 6	1.35/ 6	2.19/ 6	3.55/ 5	4.81/ 4	3.55/ 5	2.19/ 6	1.35/ 6	0.79/ 6	0.37/ 6	0.00/99
	9	0.00/99	0.35/ 8	0.74/ 8	1.20/ 8	1.79/ 6	2.62/ 6	3.34/ 6	2.62/ 6	1.79/ 6	1.20/ 8	0.74/ 8	0.35/ 8	0.00/99
	11	0.00/99	0.30/ 8	0.62/ 8	0.97/ 8	1.40/ 8	1.96/ 8	2.42/ 6	1.96/ 8	1.40/ 8	0.97/ 8	0.62/ 8	0.30/ 8	0.00/99
	13	0.00/99	0.25/10	0.52/10	0.80/10	1.12/ 8	1.51/ 8	1.84/ 8	1.51/ 8	1.12/ 8	0.80/10	0.52/10	0.25/10	0.00/99
	15	0.00/99	0.22/10	0.44/10	0.68/10	0.93/10	1.22/10	1.46/10	1.22/10	0.93/10	0.68/10	0.44/10	0.22/10	0.00/99
	17	0.00/99	0.19/10	0.38/10	0.58/10	0.78/10	1.01/10	1.19/10	1.01/10	0.78/10	0.58/10	0.38/10	0.19/10	0.00/99

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.32/ 6	0.34/ 6	0.40/ 6	0.53/ 6	0.75/ 6	1.05/ 5	1.24/ 5	1.05/ 5	0.75/ 6	0.53/ 6	0.40/ 6	0.34/ 6	0.32/ 6
	7	0.82/ 8	0.84/ 8	0.91/ 8	1.02/ 8	1.17/ 8	1.34/ 8	1.43/ 6	1.34/ 8	1.17/ 8	1.02/ 8	0.91/ 8	0.84/ 8	0.82/ 8
	9	1.07/10	1.08/10	1.13/10	1.21/10	1.31/ 8	1.41/ 8	1.45/ 8	1.41/ 8	1.31/ 8	1.21/10	1.13/10	1.08/10	1.07/10
	11	1.13/10	1.15/10	1.18/10	1.23/10	1.30/10	1.36/10	1.38/10	1.36/10	1.30/10	1.23/10	1.18/10	1.15/10	1.13/10
	13	1.39/16	1.39/16	1.41/10	1.44/10	1.48/10	1.51/10	1.53/10	1.51/10	1.48/10	1.44/10	1.41/10	1.39/16	1.39/16
	15	1.59/16	1.59/16	1.61/16	1.63/16	1.65/16	1.67/16	1.68/16	1.67/16	1.65/16	1.63/16	1.61/16	1.59/16	1.59/16
	17	1.59/16	1.59/16	1.60/16	1.62/16	1.63/16	1.65/16	1.66/16	1.65/16	1.63/16	1.62/16	1.60/16	1.59/16	1.59/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.08/ 6	0.19/ 6	0.35/ 6	0.61/ 5	1.00/ 5	1.27/ 5	1.00/ 5	0.61/ 5	0.35/ 6	0.19/ 6	0.08/ 6	0.00/99
	7	0.00/99	0.19/ 8	0.40/ 8	0.64/ 8	0.91/ 8	1.18/ 6	1.32/ 6	1.18/ 6	0.91/ 8	0.64/ 8	0.40/ 8	0.19/ 8	0.00/99
	9	0.00/99	0.24/10	0.49/10	0.75/10	1.00/ 8	1.21/ 8	1.30/ 8	1.21/ 8	1.00/ 8	0.75/10	0.49/10	0.24/10	0.00/99
	11	0.00/99	0.26/10	0.51/10	0.76/10	0.98/10	1.15/10	1.22/10	1.15/10	0.98/10	0.76/10	0.51/10	0.26/10	0.00/99
	13	0.00/99	0.31/10	0.61/10	0.88/10	1.11/10	1.27/10	1.33/10	1.27/10	1.11/10	0.88/10	0.61/10	0.31/10	0.00/99
	15	0.00/99	0.36/16	0.69/16	0.99/16	1.23/16	1.39/16	1.45/16	1.39/16	1.23/16	0.99/16	0.69/16	0.36/16	0.00/99
	17	0.00/99	0.36/16	0.69/16	0.99/16	1.22/16	1.38/16	1.43/16	1.38/16	1.22/16	0.99/16	0.69/16	0.36/16	0.00/99

ACB 90D add 10° deadrise

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.05/ 5	0.06/ 5	0.06/ 5	0.07/ 5	0.07/ 5	0.05/ 4	0.00/ 5	0.05/ 4	0.07/ 5	0.07/ 5	0.06/ 5	0.06/ 5	0.05/ 5
	7	0.07/ 6	0.07/ 6	0.07/ 6	0.07/ 6	0.06/ 6	0.04/ 5	0.00/ 6	0.04/ 5	0.06/ 6	0.07/ 6	0.07/ 6	0.07/ 6	0.07/ 6
	9	0.07/ 8	0.07/ 8	0.07/ 8	0.06/ 8	0.05/ 6	0.03/ 6	0.00/10	0.03/ 6	0.05/ 6	0.06/ 8	0.07/ 8	0.07/ 8	0.07/ 8
	11	0.06/ 8	0.06/ 8	0.05/ 8	0.05/ 8	0.04/ 8	0.02/ 8	0.00/10	0.02/ 8	0.04/ 8	0.05/ 8	0.05/ 8	0.06/ 8	0.06/ 8
	13	0.05/10	0.05/10	0.04/10	0.04/10	0.03/ 8	0.02/ 8	0.00/10	0.02/ 8	0.03/ 8	0.04/10	0.04/10	0.05/10	0.05/10
	15	0.04/10	0.04/10	0.04/10	0.03/10	0.02/10	0.01/10	0.00/16	0.01/10	0.02/10	0.03/10	0.04/10	0.04/10	0.04/10
	17	0.04/10	0.03/10	0.03/10	0.03/10	0.02/10	0.01/10	0.00/16	0.01/10	0.02/10	0.03/10	0.03/10	0.03/10	0.04/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.48/ 5	0.49/ 5	0.53/ 5	0.58/ 5	0.63/ 5	0.66/ 5	0.67/ 5	0.66/ 5	0.63/ 5	0.58/ 5	0.53/ 5	0.49/ 5	0.48/ 5
	7	0.56/ 6	0.56/ 6	0.58/ 6	0.61/ 6	0.63/ 6	0.65/ 6	0.66/ 6	0.65/ 6	0.63/ 6	0.61/ 6	0.58/ 6	0.56/ 6	0.56/ 6
	9	0.50/ 8	0.51/ 8	0.52/ 8	0.53/ 8	0.55/ 8	0.56/ 8	0.56/ 8	0.56/ 8	0.55/ 8	0.53/ 8	0.52/ 8	0.51/ 8	0.50/ 8
	11	0.42/ 8	0.42/ 8	0.43/ 8	0.44/ 8	0.45/ 8	0.45/ 8	0.45/ 8	0.45/ 8	0.45/ 8	0.44/ 8	0.43/ 8	0.42/ 8	0.42/ 8
	13	0.35/10	0.35/10	0.35/10	0.36/10	0.37/10	0.37/10	0.37/10	0.37/10	0.37/10	0.36/10	0.35/10	0.35/10	0.35/10
	15	0.30/10	0.30/10	0.30/10	0.31/10	0.31/10	0.32/10	0.32/10	0.32/10	0.31/10	0.31/10	0.30/10	0.30/10	0.30/10
	17	0.26/10	0.26/10	0.26/10	0.27/10	0.27/10	0.27/10	0.27/10	0.27/10	0.27/10	0.27/10	0.26/10	0.26/10	0.26/10

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.21/ 5	1.21/ 5	1.19/ 5	1.18/ 5	1.16/ 5	1.14/ 5	1.14/ 5	1.14/ 5	1.16/ 5	1.18/ 5	1.19/ 5	1.21/ 5	1.21/ 5
	7	1.44/ 6	1.42/ 6	1.36/ 6	1.27/ 6	1.18/ 6	1.11/ 6	1.08/ 6	1.11/ 6	1.18/ 6	1.27/ 6	1.36/ 6	1.42/ 6	1.44/ 6
	9	1.30/ 8	1.28/ 8	1.21/ 8	1.12/ 8	1.01/ 8	0.92/ 8	0.89/ 8	0.92/ 8	1.01/ 8	1.12/ 8	1.21/ 8	1.28/ 8	1.30/ 8
	11	1.07/ 8	1.05/ 8	0.99/ 8	0.91/ 8	0.81/ 8	0.74/ 8	0.71/ 8	0.74/ 8	0.81/ 8	0.91/ 8	0.99/ 8	1.05/ 8	1.07/ 8
	13	0.88/10	0.86/10	0.81/10	0.74/10	0.66/10	0.59/10	0.57/10	0.59/10	0.66/10	0.74/10	0.81/10	0.86/10	0.88/10
	15	0.75/10	0.74/10	0.69/10	0.63/10	0.56/10	0.50/10	0.48/10	0.50/10	0.56/10	0.63/10	0.69/10	0.74/10	0.75/10
	17	0.65/10	0.63/10	0.59/10	0.54/10	0.48/10	0.42/10	0.40/10	0.42/10	0.48/10	0.54/10	0.59/10	0.63/10	0.65/10

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.34/ 5	1.82/ 4	2.72/ 4	3.58/ 4	4.26/ 4	4.69/ 4	4.84/ 4	4.69/ 4	4.26/ 4	3.58/ 4	2.72/ 4	1.82/ 4	1.34/ 5
	7	1.19/ 6	1.47/ 6	2.03/ 6	2.61/ 5	3.08/ 5	3.38/ 5	3.48/ 5	3.38/ 5	3.08/ 5	2.61/ 5	2.03/ 6	1.47/ 6	1.19/ 6
	9	0.98/ 8	1.15/ 8	1.52/ 6	1.91/ 6	2.24/ 6	2.45/ 6	2.52/ 6	2.45/ 6	2.24/ 6	1.91/ 6	1.52/ 6	1.15/ 8	0.98/ 8
	11	0.77/ 8	0.89/ 8	1.15/ 8	1.43/ 8	1.66/ 8	1.81/ 8	1.87/ 8	1.81/ 8	1.66/ 8	1.43/ 8	1.15/ 8	0.89/ 8	0.77/ 8
	13	0.62/10	0.71/10	0.90/ 8	1.11/ 8	1.28/ 8	1.40/ 8	1.44/ 8	1.40/ 8	1.28/ 8	1.11/ 8	0.90/ 8	0.71/10	0.62/10
	15	0.52/10	0.58/10	0.73/10	0.89/10	1.03/10	1.12/10	1.15/10	1.12/10	1.03/10	0.89/10	0.73/10	0.58/10	0.52/10
	17	0.44/10	0.49/10	0.61/10	0.74/10	0.85/10	0.92/10	0.95/10	0.92/10	0.85/10	0.74/10	0.61/10	0.49/10	0.44/10

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.46/ 6	0.51/ 6	0.61/ 6	0.73/ 6	0.84/ 5	0.90/ 5	0.93/ 5	0.90/ 5	0.84/ 5	0.73/ 6	0.61/ 6	0.51/ 6	0.46/ 6
	7	0.93/ 8	0.96/ 8	1.02/ 8	1.10/ 8	1.17/ 8	1.22/ 8	1.24/ 8	1.22/ 8	1.17/ 8	1.10/ 8	1.02/ 8	0.96/ 8	0.93/ 8
	9	1.15/10	1.16/10	1.20/10	1.25/10	1.29/ 8	1.33/ 8	1.34/ 8	1.33/ 8	1.29/ 8	1.25/10	1.20/10	1.16/10	1.15/10
	11	1.19/10	1.20/10	1.22/10	1.25/10	1.28/10	1.30/10	1.31/10	1.30/10	1.28/10	1.25/10	1.22/10	1.20/10	1.19/10
	13	1.42/10	1.42/10	1.43/10	1.45/10	1.47/10	1.48/10	1.49/10	1.48/10	1.47/10	1.45/10	1.43/10	1.42/10	1.42/10
	15	1.61/16	1.61/16	1.62/16	1.63/16	1.64/16	1.65/16	1.65/16	1.65/16	1.64/16	1.63/16	1.62/16	1.61/16	1.61/16
	17	1.61/16	1.61/16	1.61/16	1.62/16	1.63/16	1.64/16	1.64/16	1.64/16	1.63/16	1.62/16	1.61/16	1.61/16	1.61/16

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.28/ 6	0.35/ 6	0.47/ 5	0.60/ 5	0.71/ 5	0.78/ 5	0.80/ 5	0.78/ 5	0.71/ 5	0.60/ 5	0.47/ 5	0.35/ 6	0.28/ 6
	7	0.46/ 8	0.51/ 8	0.63/ 8	0.77/ 8	0.88/ 8	0.96/ 8	0.98/ 8	0.96/ 8	0.88/ 8	0.77/ 8	0.63/ 8	0.51/ 8	0.46/ 8
	9	0.53/10	0.57/ 8	0.69/ 8	0.82/ 8	0.93/ 8	1.00/ 8	1.03/ 8	1.00/ 8	0.93/ 8	0.82/ 8	0.69/ 8	0.57/ 8	0.53/10
	11	0.53/10	0.57/10	0.67/10	0.79/10	0.90/10	0.96/10	0.99/10	0.96/10	0.90/10	0.79/10	0.67/10	0.57/10	0.53/10
	13	0.61/10	0.66/10	0.76/10	0.89/10	1.00/10	1.08/10	1.10/10	1.08/10	1.00/10	0.89/10	0.76/10	0.66/10	0.61/10
	15	0.69/16	0.73/16	0.85/16	0.99/16	1.11/16	1.19/16	1.22/16	1.19/16	1.11/16	0.99/16	0.85/16	0.73/16	0.69/16
	17	0.68/16	0.73/16	0.84/16	0.98/16	1.09/16	1.17/16	1.20/16	1.17/16	1.09/16	0.98/16	0.84/16	0.73/16	0.68/16

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.07/ 5	0.07/ 5	0.07/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.07/ 5	0.07/ 5	0.07/ 5
	7	0.08/ 6	0.08/ 6	0.07/ 6	0.07/ 6	0.06/ 6	0.06/ 6	0.06/ 6	0.06/ 6	0.06/ 6	0.07/ 6	0.07/ 6	0.08/ 6	0.08/ 6
	9	0.07/ 8	0.07/ 8	0.07/ 8	0.06/ 8	0.05/ 8	0.05/ 8	0.05/ 6	0.05/ 8	0.05/ 8	0.06/ 8	0.07/ 8	0.07/ 8	0.07/ 8
	11	0.06/ 8	0.06/ 8	0.05/ 8	0.05/ 8	0.04/ 8	0.04/ 8	0.04/ 8	0.04/ 8	0.04/ 8	0.05/ 8	0.05/ 8	0.06/ 8	0.06/ 8
	13	0.05/10	0.05/10	0.04/10	0.04/10	0.04/10	0.03/10	0.03/ 8	0.03/ 8	0.04/10	0.04/10	0.04/10	0.05/10	0.05/10
	15	0.04/10	0.04/10	0.04/10	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10	0.04/10	0.04/10	0.04/10
	17	0.03/10	0.03/10	0.03/10	0.03/10	0.02/10	0.02/10	0.02/10	0.02/10	0.02/10	0.03/10	0.03/10	0.03/10	0.03/10

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.23/ 6	0.48/ 5	0.71/ 5	0.85/ 5	0.73/ 4	0.00/ 5	0.73/ 4	0.85/ 5	0.71/ 5	0.48/ 5	0.23/ 6	0.00/99
	7	0.00/99	0.33/ 6	0.62/ 6	0.82/ 6	0.84/ 6	0.60/ 6	0.00/ 8	0.60/ 6	0.84/ 6	0.82/ 6	0.62/ 6	0.33/ 6	0.00/99
	9	0.00/99	0.32/ 8	0.58/ 8	0.74/ 8	0.71/ 8	0.47/ 8	0.00/10	0.47/ 8	0.71/ 8	0.74/ 8	0.58/ 8	0.32/ 8	0.00/99
	11	0.00/99	0.27/ 8	0.49/ 8	0.61/ 8	0.57/ 8	0.37/ 8	0.00/10	0.37/ 8	0.57/ 8	0.61/ 8	0.49/ 8	0.27/ 8	0.00/99
	13	0.00/99	0.23/10	0.41/10	0.50/10	0.47/10	0.29/10	0.00/10	0.29/10	0.47/10	0.50/10	0.41/10	0.23/10	0.00/99
	15	0.00/99	0.20/10	0.36/10	0.43/10	0.39/10	0.24/10	0.00/16	0.24/10	0.39/10	0.43/10	0.36/10	0.20/10	0.00/99
	17	0.00/99	0.18/10	0.31/10	0.37/10	0.34/10	0.21/10	0.00/16	0.21/10	0.34/10	0.37/10	0.31/10	0.18/10	0.00/99

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.11/ 5	1.14/ 5	1.23/ 5	1.34/ 5	1.38/ 5	1.08/ 4	0.00/ 4	1.08/ 4	1.38/ 5	1.34/ 5	1.23/ 5	1.14/ 5	1.11/ 5
	7	1.49/ 6	1.49/ 6	1.47/ 6	1.41/ 6	1.24/ 6	0.82/ 5	0.00/ 4	0.82/ 5	1.24/ 6	1.41/ 6	1.47/ 6	1.49/ 6	1.49/ 6
	9	1.40/ 8	1.38/ 8	1.33/ 8	1.21/ 8	0.99/ 6	0.61/ 6	0.00/10	0.61/ 6	0.99/ 6	1.21/ 8	1.33/ 8	1.38/ 8	1.40/ 8
	11	1.17/ 8	1.15/ 8	1.09/ 8	0.97/ 8	0.77/ 8	0.46/ 8	0.00/10	0.46/ 8	0.77/ 8	0.97/ 8	1.09/ 8	1.15/ 8	1.17/ 8
	13	0.97/10	0.95/10	0.89/10	0.78/10	0.61/ 8	0.36/ 8	0.00/16	0.36/ 8	0.61/ 8	0.78/10	0.89/10	0.95/10	0.97/10
	15	0.84/10	0.82/10	0.76/10	0.66/10	0.51/10	0.29/10	0.00/16	0.29/10	0.51/10	0.66/10	0.76/10	0.82/10	0.84/10
	17	0.72/10	0.71/10	0.65/10	0.56/10	0.43/10	0.24/10	0.00/16	0.24/10	0.43/10	0.56/10	0.65/10	0.71/10	0.72/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.37/ 4	0.80/ 4	1.41/ 5	2.57/ 5	5.46/ 4	8.17/ 4	5.46/ 4	2.57/ 5	1.41/ 5	0.80/ 4	0.37/ 4	0.00/99
	7	0.00/99	0.39/ 6	0.85/ 6	1.45/ 6	2.37/ 6	4.03/ 5	5.52/ 4	4.03/ 5	2.37/ 6	1.45/ 6	0.85/ 6	0.39/ 6	0.00/99
	9	0.00/99	0.37/ 8	0.78/ 8	1.26/ 8	1.90/ 6	2.92/ 6	3.81/ 4	2.92/ 6	1.90/ 6	1.26/ 8	0.78/ 8	0.37/ 8	0.00/99
	11	0.00/99	0.31/ 8	0.64/ 8	1.02/ 8	1.48/ 8	2.16/ 8	2.75/ 6	2.16/ 8	1.48/ 8	1.02/ 8	0.64/ 8	0.31/ 8	0.00/99
	13	0.00/99	0.26/10	0.54/10	0.83/10	1.18/ 8	1.66/ 8	2.07/ 8	1.66/ 8	1.18/ 8	0.83/10	0.54/10	0.26/10	0.00/99
	15	0.00/99	0.23/10	0.46/10	0.70/10	0.97/10	1.33/10	1.63/10	1.33/10	0.97/10	0.70/10	0.46/10	0.23/10	0.00/99
	17	0.00/99	0.20/10	0.40/10	0.60/10	0.81/10	1.09/10	1.32/10	1.09/10	0.81/10	0.60/10	0.40/10	0.20/10	0.00/99

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.32/ 6	0.34/ 6	0.40/ 6	0.53/ 6	0.76/ 6	1.09/ 5	1.30/ 5	1.09/ 5	0.76/ 6	0.53/ 6	0.40/ 6	0.34/ 6	0.32/ 6
	7	0.82/ 8	0.84/ 8	0.91/ 8	1.02/ 8	1.18/ 8	1.36/ 8	1.45/ 6	1.36/ 8	1.18/ 8	1.02/ 8	0.91/ 8	0.84/ 8	0.82/ 8
	9	1.07/10	1.08/10	1.13/10	1.22/10	1.32/ 8	1.42/ 8	1.47/ 8	1.42/ 8	1.32/ 8	1.22/10	1.13/10	1.08/10	1.07/10
	11	1.14/10	1.15/10	1.18/10	1.24/10	1.30/10	1.36/10	1.39/10	1.36/10	1.30/10	1.24/10	1.18/10	1.15/10	1.14/10
	13	1.39/16	1.39/16	1.41/10	1.44/10	1.48/10	1.52/10	1.53/10	1.52/10	1.48/10	1.44/10	1.41/10	1.39/16	1.39/16
	15	1.59/16	1.60/16	1.61/16	1.63/16	1.65/16	1.67/16	1.68/16	1.67/16	1.65/16	1.63/16	1.61/16	1.60/16	1.59/16
	17	1.59/16	1.60/16	1.61/16	1.62/16	1.64/16	1.65/16	1.66/16	1.65/16	1.64/16	1.62/16	1.61/16	1.60/16	1.59/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.08/ 6	0.18/ 6	0.34/ 6	0.60/ 5	0.97/ 5	1.18/ 5	0.97/ 5	0.60/ 5	0.34/ 6	0.18/ 6	0.08/ 6	0.00/99
	7	0.00/99	0.19/ 8	0.39/ 8	0.63/ 8	0.89/ 8	1.15/ 6	1.28/ 6	1.15/ 6	0.89/ 8	0.63/ 8	0.39/ 8	0.19/ 8	0.00/99
	9	0.00/99	0.24/10	0.49/10	0.74/10	0.98/ 8	1.18/ 8	1.27/ 8	1.18/ 8	0.98/ 8	0.74/10	0.49/10	0.24/10	0.00/99
	11	0.00/99	0.25/10	0.50/10	0.74/10	0.96/10	1.13/10	1.19/10	1.13/10	0.96/10	0.74/10	0.50/10	0.25/10	0.00/99
	13	0.00/99	0.30/10	0.60/10	0.86/10	1.09/10	1.24/10	1.30/10	1.24/10	1.09/10	0.86/10	0.60/10	0.30/10	0.00/99
	15	0.00/99	0.35/16	0.68/16	0.97/16	1.21/16	1.36/16	1.42/16	1.36/16	1.21/16	0.97/16	0.68/16	0.35/16	0.00/99
	17	0.00/99	0.35/16	0.68/16	0.96/16	1.19/16	1.34/16	1.40/16	1.34/16	1.19/16	0.96/16	0.68/16	0.35/16	0.00/99

ACB40C add 10° flare

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.06/ 5	0.06/ 5	0.07/ 5	0.07/ 5	0.08/ 5	0.06/ 4	0.00/ 4	0.06/ 4	0.08/ 5	0.07/ 5	0.07/ 5	0.06/ 5	0.06/ 5
	7	0.08/ 6	0.08/ 6	0.08/ 6	0.08/ 6	0.07/ 6	0.05/ 5	0.00/ 4	0.05/ 5	0.07/ 6	0.08/ 6	0.08/ 6	0.08/ 6	0.08/ 6
	9	0.08/ 8	0.07/ 8	0.07/ 8	0.07/ 8	0.05/ 6	0.03/ 6	0.00/ 4	0.03/ 6	0.05/ 6	0.07/ 8	0.07/ 8	0.07/ 8	0.08/ 8
	11	0.06/ 8	0.06/ 8	0.06/ 8	0.05/ 8	0.04/ 8	0.03/ 8	0.00/10	0.03/ 8	0.04/ 8	0.05/ 8	0.06/ 8	0.06/ 8	0.06/ 8
	13	0.05/10	0.05/10	0.05/10	0.04/ 8	0.03/ 8	0.02/ 8	0.00/16	0.02/ 8	0.03/ 8	0.04/ 8	0.05/10	0.05/10	0.05/10
	15	0.04/10	0.04/10	0.04/10	0.03/10	0.03/10	0.02/10	0.00/16	0.02/10	0.03/10	0.03/10	0.04/10	0.04/10	0.04/10
	17	0.04/10	0.04/10	0.03/10	0.03/10	0.02/10	0.01/10	0.00/16	0.01/10	0.02/10	0.03/10	0.03/10	0.04/10	0.04/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.19/ 4	1.20/ 4	1.22/ 4	1.24/ 4	1.27/ 4	1.29/ 4	1.30/ 4	1.29/ 4	1.27/ 4	1.24/ 4	1.22/ 4	1.20/ 4	1.19/ 4
	7	0.90/ 6	0.90/ 6	0.91/ 6	0.92/ 6	0.93/ 6	0.94/ 6	0.94/ 6	0.94/ 6	0.93/ 6	0.92/ 6	0.91/ 6	0.90/ 6	0.90/ 6
	9	0.69/ 8	0.69/ 8	0.70/ 8	0.70/ 8	0.71/ 8	0.71/ 8	0.71/ 8	0.71/ 8	0.71/ 8	0.70/ 8	0.70/ 8	0.69/ 8	0.69/ 8
	11	0.53/ 8	0.53/ 8	0.54/ 8	0.54/ 8	0.54/ 8	0.55/ 8	0.55/ 8	0.55/ 8	0.54/ 8	0.54/ 8	0.54/ 8	0.53/ 8	0.53/ 8
	13	0.42/10	0.43/10	0.43/10	0.43/10	0.43/10	0.43/10	0.43/10	0.43/10	0.43/10	0.43/10	0.43/10	0.43/10	0.42/10
	15	0.35/10	0.35/10	0.35/10	0.36/10	0.36/10	0.36/10	0.36/10	0.36/10	0.36/10	0.36/10	0.35/10	0.35/10	0.35/10
	17	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10	0.30/10

1

AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	3.63/ 4	3.56/ 4	3.34/ 4	3.03/ 4	2.67/ 4	2.38/ 4	2.26/ 4	2.38/ 4	2.67/ 4	3.03/ 4	3.34/ 4	3.56/ 4	3.63/ 4
	7	2.80/ 5	2.74/ 5	2.56/ 5	2.31/ 5	2.02/ 5	1.78/ 5	1.69/ 5	1.78/ 5	2.02/ 5	2.31/ 5	2.56/ 5	2.74/ 5	2.80/ 5
	9	2.09/ 6	2.05/ 6	1.92/ 6	1.72/ 6	1.50/ 6	1.32/ 6	1.25/ 6	1.32/ 6	1.50/ 6	1.72/ 6	1.92/ 6	2.05/ 6	2.09/ 6
	11	1.58/ 8	1.54/ 8	1.44/ 8	1.30/ 8	1.13/ 8	0.99/ 8	0.93/ 8	0.99/ 8	1.13/ 8	1.30/ 8	1.44/ 8	1.54/ 8	1.58/ 8
	13	1.23/ 8	1.20/ 8	1.12/ 8	1.01/ 8	0.88/ 8	0.77/ 8	0.73/ 8	0.77/ 8	0.88/ 8	1.01/ 8	1.12/ 8	1.20/ 8	1.23/ 8
	15	1.00/10	0.98/10	0.91/10	0.82/10	0.71/10	0.62/10	0.59/10	0.62/10	0.71/10	0.82/10	0.91/10	0.98/10	1.00/10
	17	0.83/10	0.81/10	0.76/10	0.68/10	0.59/10	0.52/10	0.49/10	0.52/10	0.59/10	0.68/10	0.76/10	0.81/10	0.83/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	2.78/ 4	3.06/ 4	3.74/ 4	4.49/ 4	5.13/ 4	5.55/ 4	5.69/ 4	5.55/ 4	5.13/ 4	4.49/ 4	3.74/ 4	3.06/ 4	2.78/ 4
	7	2.01/ 5	2.19/ 5	2.62/ 5	3.11/ 5	3.53/ 5	3.81/ 4	3.91/ 4	3.81/ 4	3.53/ 5	3.11/ 5	2.62/ 5	2.19/ 5	2.01/ 5
	9	1.45/ 6	1.57/ 6	1.86/ 6	2.20/ 6	2.49/ 6	2.68/ 6	2.75/ 6	2.68/ 6	2.49/ 6	2.20/ 6	1.86/ 6	1.57/ 6	1.45/ 6
	11	1.07/ 8	1.15/ 8	1.36/ 8	1.61/ 8	1.81/ 6	1.95/ 6	2.00/ 6	1.95/ 6	1.81/ 6	1.61/ 8	1.36/ 8	1.15/ 8	1.07/ 8
	13	0.82/ 8	0.88/ 8	1.04/ 8	1.22/ 8	1.38/ 8	1.49/ 8	1.52/ 8	1.49/ 8	1.38/ 8	1.22/ 8	1.04/ 8	0.88/ 8	0.82/ 8
	15	0.66/10	0.71/10	0.83/10	0.97/10	1.10/10	1.18/10	1.21/10	1.18/10	1.10/10	0.97/10	0.83/10	0.71/10	0.66/10
	17	0.54/10	0.58/10	0.68/10	0.80/10	0.90/10	0.97/10	0.99/10	0.97/10	0.90/10	0.80/10	0.68/10	0.58/10	0.54/10

1

AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.51/ 5	0.55/ 5	0.64/ 5	0.75/ 5	0.85/ 5	0.91/ 5	0.93/ 5	0.91/ 5	0.85/ 5	0.75/ 5	0.64/ 5	0.55/ 5	0.51/ 5
	7	0.60/ 6	0.64/ 6	0.74/ 6	0.86/ 6	0.97/ 6	1.04/ 6	1.06/ 6	1.04/ 6	0.97/ 6	0.86/ 6	0.74/ 6	0.64/ 6	0.60/ 6
	9	0.61/ 8	0.65/ 8	0.76/ 8	0.87/ 8	0.98/ 8	1.05/ 8	1.07/ 8	1.05/ 8	0.98/ 8	0.87/ 8	0.76/ 8	0.65/ 8	0.61/ 8
	11	0.59/10	0.62/10	0.72/10	0.83/10	0.93/10	1.00/10	1.02/10	1.00/10	0.93/10	0.83/10	0.72/10	0.62/10	0.59/10
	13	0.65/10	0.69/10	0.79/10	0.92/10	1.03/10	1.10/10	1.12/10	1.10/10	1.03/10	0.92/10	0.79/10	0.69/10	0.65/10
	15	0.71/16	0.76/16	0.87/16	1.01/16	1.13/16	1.21/16	1.24/16	1.21/16	1.13/16	1.01/16	0.87/16	0.76/16	0.71/16
	17	0.70/16	0.75/16	0.86/16	0.99/16	1.11/16	1.19/16	1.22/16	1.19/16	1.11/16	0.99/16	0.86/16	0.75/16	0.70/16

1

AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.21/ 4	0.20/ 4	0.19/ 4	0.17/ 4	0.15/ 4	0.14/ 4	0.13/ 4	0.14/ 4	0.15/ 4	0.17/ 4	0.19/ 4	0.20/ 4	0.21/ 4
	7	0.16/ 5	0.16/ 5	0.15/ 5	0.13/ 5	0.12/ 5	0.10/ 5	0.10/ 5	0.10/ 5	0.12/ 5	0.13/ 5	0.15/ 5	0.16/ 5	0.16/ 5
	9	0.12/ 6	0.12/ 6	0.11/ 6	0.10/ 6	0.09/ 6	0.07/ 6	0.07/ 6	0.07/ 6	0.09/ 6	0.10/ 6	0.11/ 6	0.12/ 6	0.12/ 6
	11	0.09/ 8	0.09/ 8	0.08/ 8	0.07/ 8	0.06/ 8	0.06/ 8	0.05/ 8	0.06/ 8	0.06/ 8	0.07/ 8	0.08/ 8	0.09/ 8	0.09/ 8
	13	0.07/ 8	0.07/ 8	0.06/ 8	0.06/ 8	0.05/ 8	0.04/ 8	0.04/ 8	0.04/ 8	0.05/ 8	0.06/ 8	0.06/ 8	0.07/ 8	0.07/ 8
	15	0.06/10	0.05/10	0.05/10	0.05/10	0.04/10	0.03/10	0.03/10	0.03/10	0.04/10	0.05/10	0.05/10	0.05/10	0.06/10
	17	0.05/10	0.04/10	0.04/10	0.04/10	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10	0.04/10	0.04/10	0.04/10	0.05/10

1

AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.07/ 5	1.08/ 5	1.10/ 5	1.13/ 5	1.16/ 5	1.18/ 5	1.19/ 5	1.18/ 5	1.16/ 5	1.13/ 5	1.10/ 5	1.08/ 5	1.07/ 5
	7	1.35/ 8	1.35/ 8	1.36/ 8	1.37/ 6	1.39/ 6	1.40/ 6	1.40/ 6	1.40/ 6	1.39/ 6	1.37/ 6	1.36/ 8	1.35/ 8	1.35/ 8
	9	1.41/ 8	1.41/ 8	1.42/ 8	1.42/ 8	1.43/ 8	1.44/ 8	1.44/ 8	1.44/ 8	1.43/ 8	1.42/ 8	1.42/ 8	1.41/ 8	1.41/ 8
	11	1.35/10	1.36/10	1.36/10	1.36/10	1.37/10	1.37/10	1.37/10	1.37/10	1.37/10	1.36/10	1.36/10	1.36/10	1.35/10
	13	1.51/10	1.51/10	1.51/10	1.51/10	1.51/10	1.52/10	1.52/10	1.52/10	1.51/10	1.51/10	1.51/10	1.51/10	1.51/10
	15	1.66/16	1.66/16	1.67/16	1.67/16	1.67/16	1.67/16	1.67/16	1.67/16	1.67/16	1.67/16	1.67/16	1.66/16	1.66/16
	17	1.64/16	1.64/16	1.64/16	1.64/16	1.65/16	1.65/16	1.65/16	1.65/16	1.65/16	1.64/16	1.64/16	1.64/16	1.64/16

1

AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.77/ 4	1.39/ 4	1.72/ 4	1.64/ 4	1.04/ 3	0.00/ 5	1.04/ 3	1.64/ 4	1.72/ 4	1.39/ 4	0.77/ 4	0.00/99
	7	0.00/99	0.61/ 6	1.08/ 6	1.29/ 6	1.18/ 6	0.71/ 6	0.00/ 6	0.71/ 6	1.18/ 6	1.29/ 6	1.08/ 6	0.61/ 6	0.00/99
	9	0.00/99	0.48/ 8	0.84/ 8	0.99/ 8	0.88/ 8	0.53/ 8	0.00/10	0.53/ 8	0.88/ 8	0.99/ 8	0.84/ 8	0.48/ 8	0.00/99
	11	0.00/99	0.37/ 8	0.65/ 8	0.76/ 8	0.68/ 8	0.40/ 8	0.00/10	0.40/ 8	0.68/ 8	0.76/ 8	0.65/ 8	0.37/ 8	0.00/99
	13	0.00/99	0.30/10	0.52/10	0.60/10	0.53/10	0.32/10	0.00/10	0.32/10	0.53/10	0.60/10	0.52/10	0.30/10	0.00/99
	15	0.00/99	0.25/10	0.43/10	0.50/10	0.44/10	0.26/10	0.00/16	0.26/10	0.44/10	0.50/10	0.43/10	0.25/10	0.00/99
	17	0.00/99	0.21/10	0.36/10	0.42/10	0.37/10	0.22/10	0.00/16	0.22/10	0.37/10	0.42/10	0.36/10	0.21/10	0.00/99

1

AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	4.05/ 4	3.96/ 4	3.69/ 4	3.18/ 4	2.38/ 4	1.29/ 4	0.00/ 4	1.29/ 4	2.38/ 4	3.18/ 4	3.69/ 4	3.96/ 4	4.05/ 4
	7	3.16/ 5	3.08/ 5	2.82/ 5	2.38/ 5	1.74/ 5	0.93/ 5	0.00/ 5	0.93/ 5	1.74/ 5	2.38/ 5	2.82/ 5	3.08/ 5	3.16/ 5
	9	2.38/ 6	2.31/ 6	2.11/ 6	1.76/ 6	1.28/ 6	0.67/ 6	0.00/ 5	0.67/ 6	1.28/ 6	1.76/ 6	2.11/ 6	2.31/ 6	2.38/ 6
	11	1.80/ 8	1.74/ 8	1.59/ 8	1.32/ 8	0.95/ 8	0.50/ 8	0.00/ 5	0.50/ 8	0.95/ 8	1.32/ 8	1.59/ 8	1.74/ 8	1.80/ 8
	13	1.40/ 8	1.36/ 8	1.23/ 8	1.02/ 8	0.74/ 8	0.39/ 8	0.00/16	0.39/ 8	0.74/ 8	1.02/ 8	1.23/ 8	1.36/ 8	1.40/ 8
	15	1.14/10	1.11/10	1.00/10	0.83/10	0.60/10	0.31/10	0.00/16	0.31/10	0.60/10	0.83/10	1.00/10	1.11/10	1.14/10
	17	0.95/10	0.92/10	0.83/10	0.69/10	0.49/10	0.26/10	0.00/16	0.26/10	0.49/10	0.69/10	0.83/10	0.92/10	0.95/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	1.16/ 4	2.41/ 4	3.83/ 4	5.36/ 4	6.62/ 4	7.13/ 4	6.62/ 4	5.36/ 4	3.83/ 4	2.41/ 4	1.16/ 4	0.00/99
	7	0.00/99	0.90/ 5	1.83/ 5	2.80/ 5	3.75/ 5	4.50/ 4	4.80/ 4	4.50/ 4	3.75/ 5	2.80/ 5	1.83/ 5	0.90/ 5	0.00/99
	9	0.00/99	0.67/ 6	1.35/ 6	2.02/ 6	2.66/ 6	3.14/ 6	3.33/ 6	3.14/ 6	2.66/ 6	2.02/ 6	1.35/ 6	0.67/ 6	0.00/99
	11	0.00/99	0.51/ 8	1.01/ 8	1.50/ 8	1.95/ 8	2.29/ 6	2.42/ 6	2.29/ 6	1.95/ 8	1.50/ 8	1.01/ 8	0.51/ 8	0.00/99
	13	0.00/99	0.39/ 8	0.78/ 8	1.15/ 8	1.49/ 8	1.74/ 8	1.83/ 8	1.74/ 8	1.49/ 8	1.15/ 8	0.78/ 8	0.39/ 8	0.00/99
	15	0.00/99	0.32/10	0.63/10	0.92/10	1.18/10	1.38/10	1.45/10	1.38/10	1.18/10	0.92/10	0.63/10	0.32/10	0.00/99
	17	0.00/99	0.26/10	0.52/10	0.76/10	0.97/10	1.12/10	1.18/10	1.12/10	0.97/10	0.76/10	0.52/10	0.26/10	0.00/99

1

AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.24/ 5	0.49/ 5	0.72/ 5	0.92/ 5	1.05/ 5	1.10/ 5	1.05/ 5	0.92/ 5	0.72/ 5	0.49/ 5	0.24/ 5	0.00/99
	7	0.00/99	0.30/ 8	0.59/ 6	0.85/ 6	1.05/ 6	1.19/ 6	1.24/ 6	1.19/ 6	1.05/ 6	0.85/ 6	0.59/ 6	0.30/ 8	0.00/99
	9	0.00/99	0.31/ 8	0.61/ 8	0.87/ 8	1.07/ 8	1.20/ 8	1.25/ 8	1.20/ 8	1.07/ 8	0.87/ 8	0.61/ 8	0.31/ 8	0.00/99
	11	0.00/99	0.30/10	0.58/10	0.83/10	1.02/10	1.14/10	1.18/10	1.14/10	1.02/10	0.83/10	0.58/10	0.30/10	0.00/99
	13	0.00/99	0.33/10	0.65/10	0.92/10	1.12/10	1.26/10	1.30/10	1.26/10	1.12/10	0.92/10	0.65/10	0.33/10	0.00/99
	15	0.00/99	0.37/16	0.71/16	1.01/16	1.24/16	1.38/16	1.43/16	1.38/16	1.24/16	1.01/16	0.71/16	0.37/16	0.00/99
	17	0.00/99	0.36/16	0.70/16	0.99/16	1.22/16	1.36/16	1.41/16	1.36/16	1.22/16	0.99/16	0.70/16	0.36/16	0.00/99

1

AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.23/ 4	0.23/ 4	0.21/ 4	0.18/ 4	0.14/ 4	0.07/ 4	0.00/ 4	0.07/ 4	0.14/ 4	0.18/ 4	0.21/ 4	0.23/ 4	0.23/ 4
	7	0.18/ 5	0.18/ 5	0.16/ 5	0.14/ 5	0.10/ 5	0.05/ 5	0.00/ 5	0.05/ 5	0.10/ 5	0.14/ 5	0.16/ 5	0.18/ 5	0.18/ 5
	9	0.13/ 6	0.13/ 6	0.12/ 6	0.10/ 6	0.07/ 6	0.04/ 6	0.00/ 5	0.04/ 6	0.07/ 6	0.10/ 6	0.12/ 6	0.13/ 6	0.13/ 6
	11	0.10/ 8	0.10/ 8	0.09/ 8	0.07/ 8	0.05/ 8	0.03/ 8	0.00/10	0.03/ 8	0.05/ 8	0.07/ 8	0.09/ 8	0.10/ 8	0.10/ 8
	13	0.08/ 8	0.08/ 8	0.07/ 8	0.06/ 8	0.04/ 8	0.02/ 8	0.00/16	0.02/ 8	0.04/ 8	0.06/ 8	0.07/ 8	0.08/ 8	0.08/ 8
	15	0.06/10	0.06/10	0.06/10	0.05/10	0.03/10	0.02/10	0.00/16	0.02/10	0.03/10	0.05/10	0.06/10	0.06/10	0.06/10
	17	0.05/10	0.05/10	0.05/10	0.04/10	0.03/10	0.01/10	0.00/16	0.01/10	0.03/10	0.04/10	0.05/10	0.05/10	0.05/10

1

AMPHIBIOUS CARGO BEACHING LIGHTER SINGLE 40 FOOT MODULE

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.02/ 5	1.03/ 5	1.07/ 5	1.12/ 5	1.19/ 5	1.24/ 5	1.25/ 5	1.24/ 5	1.19/ 5	1.12/ 5	1.07/ 5	1.03/ 5	1.02/ 5
	7	1.32/ 8	1.33/ 8	1.35/ 8	1.37/ 6	1.40/ 6	1.42/ 6	1.43/ 6	1.42/ 6	1.40/ 6	1.37/ 6	1.35/ 8	1.33/ 8	1.32/ 8
	9	1.40/ 8	1.40/ 8	1.41/ 8	1.42/ 8	1.44/ 8	1.45/ 8	1.45/ 8	1.45/ 8	1.44/ 8	1.42/ 8	1.41/ 8	1.40/ 8	1.40/ 8
	11	1.35/10	1.35/10	1.35/10	1.36/10	1.37/10	1.38/10	1.38/10	1.38/10	1.37/10	1.36/10	1.35/10	1.35/10	1.35/10
	13	1.50/10	1.50/10	1.51/10	1.51/10	1.52/10	1.52/10	1.52/10	1.52/10	1.52/10	1.51/10	1.51/10	1.50/10	1.50/10
	15	1.66/16	1.66/16	1.66/16	1.67/16	1.67/16	1.67/16	1.67/16	1.67/16	1.67/16	1.67/16	1.66/16	1.66/16	1.66/16
	17	1.64/16	1.64/16	1.64/16	1.64/16	1.65/16	1.65/16	1.65/16	1.65/16	1.65/16	1.64/16	1.64/16	1.64/16	1.64/16

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Figure B-8. Surge, heave, and sway response, sea state 2.5, 1 module.

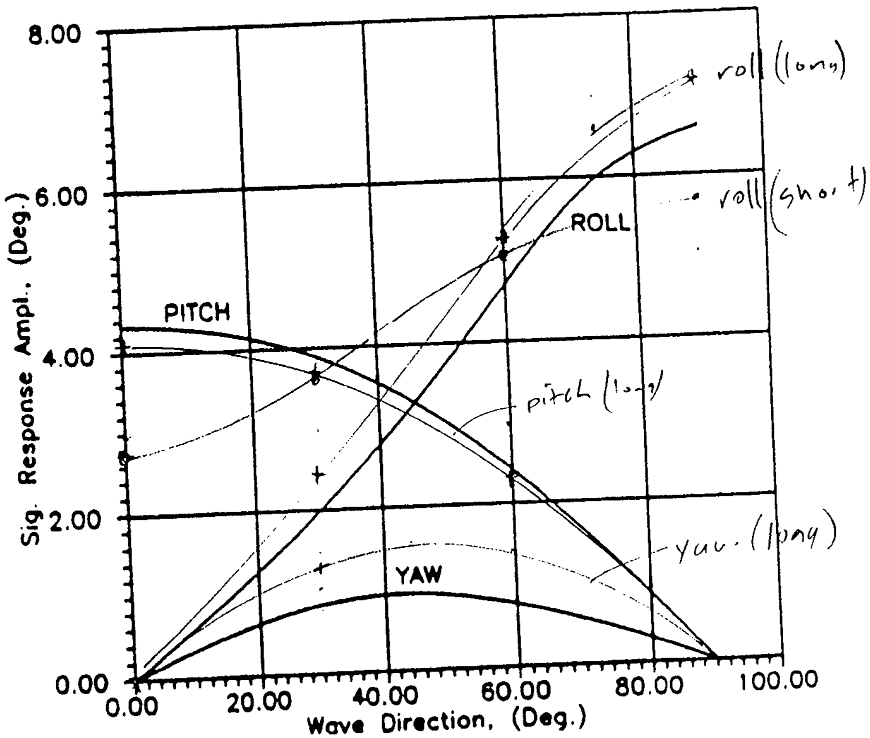

Figure B-9. Roll, yaw, and pitch response, sea state 2.5, 1 module.

:han ships in
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:he head seas
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: results and

(end-to-end)
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end-to-end,
ges was 1.2
the response

heave and sway reasonable long crested

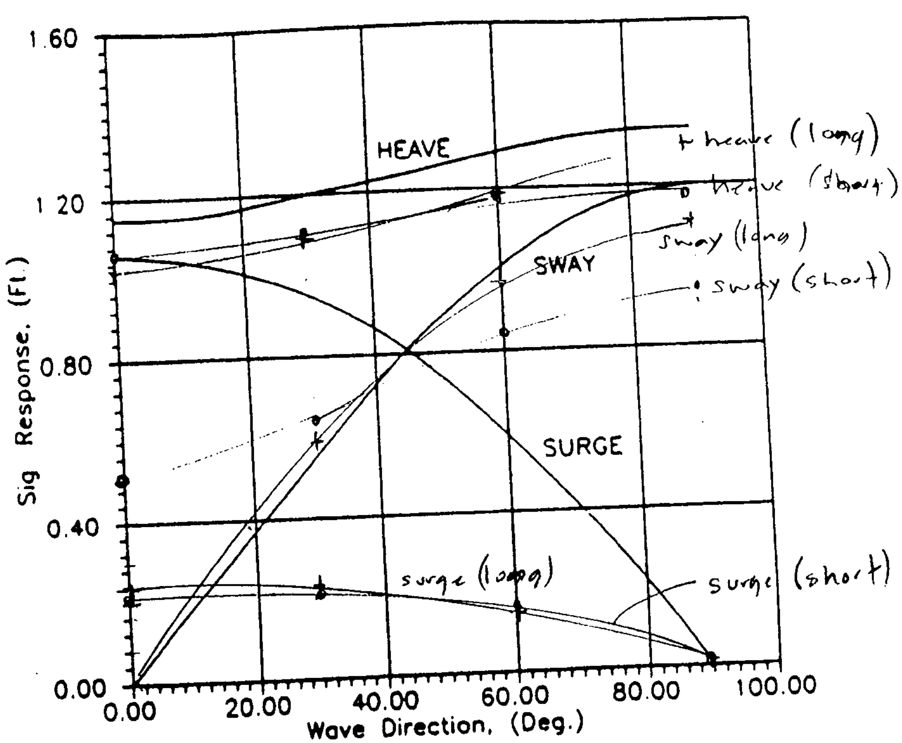

Figure B-8. Surge, heave, and sway response, sea state 2.5, 1 module.

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.46/ 5	0.48/ 5	0.52/ 5	0.57/ 5	0.61/ 5	0.65/ 5	0.66/ 5	0.65/ 5	0.61/ 5	0.57/ 5	0.52/ 5	0.48/ 5	0.46/ 5
	7	0.54/ 6	0.55/ 6	0.57/ 6	0.59/ 6	0.62/ 6	0.63/ 6	0.64/ 6	0.63/ 6	0.62/ 6	0.59/ 6	0.57/ 6	0.55/ 6	0.54/ 6
	9	0.49/ 8	0.50/ 8	0.51/ 8	0.52/ 8	0.54/ 8	0.55/ 8	0.55/ 8	0.55/ 8	0.54/ 8	0.52/ 8	0.51/ 8	0.50/ 8	0.49/ 8
	11	0.41/ 8	0.41/ 8	0.42/ 8	0.43/ 8	0.44/ 8	0.44/ 8	0.45/ 8	0.44/ 8	0.44/ 8	0.43/ 8	0.42/ 8	0.41/ 8	0.41/ 8
	13	0.34/10	0.34/10	0.35/10	0.36/10	0.36/10	0.37/10	0.37/10	0.37/10	0.36/10	0.36/10	0.35/10	0.34/10	0.34/10
	15	0.30/10	0.30/10	0.30/10	0.31/10	0.31/10	0.31/10	0.31/10	0.31/10	0.31/10	0.31/10	0.30/10	0.30/10	0.30/10
	17	0.26/10	0.26/10	0.26/10	0.26/10	0.27/10	0.27/10	0.27/10	0.27/10	0.27/10	0.26/10	0.26/10	0.26/10	0.26/10

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.20/ 5	1.19/ 5	1.18/ 5	1.16/ 5	1.13/ 5	1.12/ 5	1.11/ 5	1.12/ 5	1.13/ 5	1.16/ 5	1.18/ 5	1.19/ 5	1.20/ 5
	7	1.43/ 6	1.41/ 6	1.35/ 6	1.26/ 6	1.16/ 6	1.09/ 6	1.06/ 6	1.09/ 6	1.16/ 6	1.26/ 6	1.35/ 6	1.41/ 6	1.43/ 6
	9	1.29/ 8	1.27/ 8	1.20/ 8	1.11/ 8	1.00/ 8	0.91/ 8	0.88/ 8	0.91/ 8	1.00/ 8	1.11/ 8	1.20/ 8	1.27/ 8	1.29/ 8
	11	1.06/ 8	1.04/ 8	0.98/ 8	0.90/ 8	0.81/ 8	0.73/ 8	0.70/ 8	0.73/ 8	0.81/ 8	0.90/ 8	0.98/ 8	1.04/ 8	1.06/ 8
	13	0.88/10	0.86/10	0.81/10	0.74/10	0.66/10	0.59/10	0.56/10	0.59/10	0.66/10	0.74/10	0.81/10	0.86/10	0.88/10
	15	0.75/10	0.73/10	0.69/10	0.62/10	0.55/10	0.49/10	0.47/10	0.49/10	0.55/10	0.62/10	0.69/10	0.73/10	0.75/10
	17	0.64/10	0.63/10	0.59/10	0.53/10	0.47/10	0.42/10	0.40/10	0.42/10	0.47/10	0.53/10	0.59/10	0.63/10	0.64/10

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.15/ 5	1.54/ 5	2.29/ 4	3.03/ 4	3.61/ 4	3.99/ 4	4.12/ 4	3.99/ 4	3.61/ 4	3.03/ 4	2.29/ 4	1.54/ 5	1.15/ 5
	7	1.08/ 6	1.30/ 6	1.78/ 6	2.28/ 6	2.69/ 5	2.95/ 5	3.04/ 5	2.95/ 5	2.69/ 5	2.28/ 6	1.78/ 6	1.30/ 6	1.08/ 6
	9	0.90/ 8	1.05/ 8	1.37/ 6	1.71/ 6	1.99/ 6	2.18/ 6	2.24/ 6	2.18/ 6	1.99/ 6	1.71/ 6	1.37/ 6	1.05/ 8	0.90/ 8
	11	0.72/ 8	0.82/ 8	1.05/ 8	1.29/ 8	1.50/ 8	1.63/ 8	1.68/ 8	1.63/ 8	1.50/ 8	1.29/ 8	1.05/ 8	0.82/ 8	0.72/ 8
	13	0.58/10	0.66/10	0.82/ 8	1.01/ 8	1.16/ 8	1.27/ 8	1.30/ 8	1.27/ 8	1.16/ 8	1.01/ 8	0.82/ 8	0.66/10	0.58/10
	15	0.49/10	0.55/10	0.68/10	0.82/10	0.94/10	1.02/10	1.05/10	1.02/10	0.94/10	0.82/10	0.68/10	0.55/10	0.49/10
	17	0.42/10	0.46/10	0.57/10	0.68/10	0.78/10	0.85/10	0.87/10	0.85/10	0.78/10	0.68/10	0.57/10	0.46/10	0.42/10

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.46/ 6	0.50/ 6	0.60/ 6	0.72/ 6	0.82/ 5	0.88/ 5	0.90/ 5	0.88/ 5	0.82/ 5	0.72/ 6	0.60/ 6	0.50/ 6	0.46/ 6
	7	0.92/ 8	0.95/ 8	1.01/ 8	1.08/ 8	1.16/ 8	1.21/ 8	1.22/ 8	1.21/ 8	1.16/ 8	1.08/ 8	1.01/ 8	0.95/ 8	0.92/ 8
	9	1.14/10	1.15/10	1.19/10	1.24/10	1.28/ 8	1.32/ 8	1.33/ 8	1.32/ 8	1.28/ 8	1.24/10	1.19/10	1.15/10	1.14/10
	11	1.18/10	1.19/10	1.21/10	1.24/10	1.27/10	1.29/10	1.30/10	1.29/10	1.27/10	1.24/10	1.21/10	1.19/10	1.18/10
	13	1.41/10	1.41/10	1.43/10	1.44/10	1.46/10	1.47/10	1.48/10	1.47/10	1.46/10	1.44/10	1.43/10	1.41/10	1.41/10
	15	1.60/16	1.60/16	1.61/16	1.62/16	1.63/16	1.64/16	1.64/16	1.64/16	1.63/16	1.62/16	1.61/16	1.60/16	1.60/16
	17	1.60/16	1.60/16	1.60/16	1.61/16	1.62/16	1.63/16	1.63/16	1.63/16	1.62/16	1.61/16	1.60/16	1.60/16	1.60/16

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.27/ 6	0.32/ 6	0.44/ 5	0.56/ 5	0.66/ 5	0.73/ 5	0.75/ 5	0.73/ 5	0.66/ 5	0.56/ 5	0.44/ 5	0.32/ 6	0.27/ 6
	7	0.45/ 8	0.50/ 8	0.62/ 8	0.75/ 8	0.86/ 8	0.93/ 8	0.95/ 8	0.93/ 8	0.86/ 8	0.75/ 8	0.62/ 8	0.50/ 8	0.45/ 8
	9	0.52/10	0.57/10	0.68/ 8	0.81/ 8	0.92/ 8	0.99/ 8	1.01/ 8	0.99/ 8	0.92/ 8	0.81/ 8	0.68/ 8	0.57/10	0.52/10
	11	0.53/10	0.57/10	0.67/10	0.79/10	0.89/10	0.96/10	0.98/10	0.96/10	0.89/10	0.79/10	0.67/10	0.57/10	0.53/10
	13	0.62/10	0.66/10	0.77/10	0.89/10	1.00/10	1.08/10	1.10/10	1.08/10	1.00/10	0.89/10	0.77/10	0.66/10	0.62/10
	15	0.69/16	0.74/16	0.86/16	0.99/16	1.11/16	1.19/16	1.22/16	1.19/16	1.11/16	0.99/16	0.86/16	0.74/16	0.69/16
	17	0.69/16	0.73/16	0.85/16	0.98/16	1.10/16	1.18/16	1.21/16	1.18/16	1.10/16	0.98/16	0.85/16	0.73/16	0.69/16

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

SHORTCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90.	105	120	135	150	165	FOLLOW 180
0	5	0.07/ 5	0.07/ 5	0.07/ 5	0.07/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.06/ 5	0.07/ 5	0.07/ 5	0.07/ 5	0.07/ 5
	7	0.08/ 6	0.08/ 6	0.08/ 6	0.07/ 6	0.07/ 6	0.06/ 6	0.06/ 6	0.06/ 6	0.07/ 6	0.07/ 6	0.08/ 6	0.08/ 6	0.08/ 6
	9	0.07/ 8	0.07/ 8	0.07/ 8	0.06/ 8	0.06/ 8	0.05/ 8	0.05/ 6	0.05/ 8	0.06/ 8	0.06/ 8	0.07/ 8	0.07/ 8	0.07/ 8
	11	0.06/ 8	0.06/ 8	[illegible]	0.05/ 8	0.05/ 8	0.04/ 8	0.04/ 8	0.04/ 8	0.05/ 8	0.05/ 8	0.06/ 8	0.06/ 8	0.06/ 8
	13	0.05/10	0.05/10	0.04/10	0.04/10	0.04/10	0.03/ 8	0.03/ 8	0.03/ 8	0.04/10	0.04/10	0.04/10	0.05/10	0.05/10
	15	0.04/10	0.04/10	0.04/10	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10	0.04/10	0.04/10	0.04/10
	17	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10	0.02/10	0.02/10	0.02/10	0.03/10	0.03/10	0.03/10	0.03/10	0.03/10

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

YAW ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.23/ 6	0.46/ 5	0.68/ 5	0.82/ 5	0.74/ 4	0.00/ 5	0.74/ 4	0.82/ 5	0.68/ 5	0.46/ 5	0.23/ 6	0.00/99
	7	0.00/99	0.32/ 6	0.60/ 6	0.79/ 6	0.81/ 6	0.59/ 6	0.00/ 5	0.59/ 6	0.81/ 6	0.79/ 6	0.60/ 6	0.32/ 6	0.00/99
	9	0.00/99	0.31/ 8	0.57/ 8	0.72/ 8	0.69/ 8	0.46/ 8	0.00/10	0.46/ 8	0.69/ 8	0.72/ 8	0.57/ 8	0.31/ 8	0.00/99
	11	0.00/99	0.27/ 8	0.48/ 8	0.59/ 8	0.56/ 8	0.36/ 8	0.00/10	0.36/ 8	0.56/ 8	0.59/ 8	0.48/ 8	0.27/ 8	0.00/99
	13	0.00/99	0.23/10	0.41/10	0.49/10	0.46/10	0.29/10	0.00/10	0.29/10	0.46/10	0.49/10	0.41/10	0.23/10	0.00/99
	15	0.00/99	0.20/10	0.36/10	0.43/10	0.39/10	0.24/10	0.00/10	0.24/10	0.39/10	0.43/10	0.36/10	0.20/10	0.00/99
	17	0.00/99	0.18/10	0.31/10	0.37/10	0.34/10	0.21/10	0.00/16	0.21/10	0.34/10	0.37/10	0.31/10	0.18/10	0.00/99

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

PITCH ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	1.10/ 5	1.13/ 5	1.22/ 5	1.32/ 5	1.35/ 5	1.04/ 4	0.00/ 3	1.04/ 4	1.35/ 5	1.32/ 5	1.22/ 5	1.13/ 5	1.10/ 5
	7	1.48/ 6	1.48/ 6	1.46/ 6	1.40/ 6	1.22/ 6	0.80/ 5	0.00/ 6	0.80/ 5	1.22/ 6	1.40/ 6	1.46/ 6	1.48/ 6	1.48/ 6
	9	1.39/ 8	1.37/ 8	1.32/ 8	1.20/ 8	0.98/ 6	0.60/ 6	0.00/ 6	0.60/ 6	0.98/ 6	1.20/ 8	1.32/ 8	1.37/ 8	1.39/ 8
	11	1.16/ 8	1.14/ 8	1.08/ 8	0.96/ 8	0.76/ 8	0.45/ 8	0.00/10	0.45/ 8	0.76/ 8	0.96/ 8	1.08/ 8	1.14/ 8	1.16/ 8
	13	0.97/10	0.95/10	0.89/10	0.78/10	0.61/ 8	0.35/ 8	0.00/10	0.35/ 8	0.61/ 8	0.78/10	0.89/10	0.95/10	0.97/10
	15	0.83/10	0.81/10	0.75/10	0.65/10	0.50/10	0.29/10	0.00/16	0.29/10	0.50/10	0.65/10	0.75/10	0.81/10	0.83/10
	17	0.72/10	0.70/10	0.65/10	0.56/10	0.42/10	0.24/10	0.00/16	0.24/10	0.42/10	0.56/10	0.65/10	0.70/10	0.72/10

1 AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

ROLL ANGLE
(DEG)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.32/ 4	0.69/ 6	1.23/ 5	2.28/ 5	4.64/ 4	7.13/ 4	4.64/ 4	2.28/ 5	1.23/ 5	0.69/ 6	0.32/ 4	0.00/99
	7	0.00/99	0.36/ 6	0.78/ 6	1.33/ 6	2.16/ 6	3.53/ 5	4.80/ 4	3.53/ 5	2.16/ 6	1.33/ 6	0.78/ 6	0.36/ 6	0.00/99
	9	0.00/99	0.35/ 8	0.73/ 8	1.18/ 8	1.77/ 6	2.60/ 6	3.33/ 6	2.60/ 6	1.77/ 6	1.18/ 8	0.73/ 8	0.35/ 8	0.00/99
	11	0.00/99	0.30/ 8	0.61/ 8	0.96/ 8	1.39/ 8	1.94/ 8	2.42/ 6	1.94/ 8	1.39/ 8	0.96/ 8	0.61/ 8	0.30/ 8	0.00/99
	13	0.00/99	0.25/10	0.51/10	0.79/10	1.11/ 8	1.50/ 8	1.83/ 8	1.50/ 8	1.11/ 8	0.79/10	0.51/10	0.25/10	0.00/99
	15	0.00/99	0.22/10	0.44/10	0.67/10	0.92/10	1.21/10	1.45/10	1.21/10	0.92/10	0.67/10	0.44/10	0.22/10	0.00/99
	17	0.00/99	0.19/10	0.38/10	0.57/10	0.77/10	1.00/10	1.18/10	1.00/10	0.77/10	0.57/10	0.38/10	0.19/10	0.00/99

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AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

HEAVE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.32/ 6	0.33/ 6	0.40/ 6	0.53/ 6	0.75/ 6	1.06/ 5	1.25/ 5	1.06/ 5	0.75/ 6	0.53/ 6	0.40/ 6	0.33/ 6	0.32/ 6
	7	0.81/ 8	0.83/ 8	0.90/ 8	1.01/ 8	1.17/ 8	1.34/ 8	1.43/ 6	1.34/ 8	1.17/ 8	1.01/ 8	0.90/ 8	0.83/ 8	0.81/ 8
	9	1.06/10	1.08/10	1.13/10	1.21/10	1.31/ 8	1.40/ 8	1.45/ 8	1.40/ 8	1.31/ 8	1.21/10	1.13/10	1.08/10	1.06/10
	11	1.13/10	1.14/10	1.17/10	1.23/10	1.29/10	1.35/10	1.38/10	1.35/10	1.29/10	1.23/10	1.17/10	1.14/10	1.13/10
	13	1.38/16	1.39/16	1.41/10	1.44/10	1.47/10	1.51/10	1.52/10	1.51/10	1.47/10	1.44/10	1.41/10	1.39/16	1.38/16
	15	1.58/16	1.59/16	1.60/16	1.62/16	1.64/16	1.66/16	1.67/16	1.66/16	1.64/16	1.62/16	1.60/16	1.59/16	1.58/16
	17	1.58/16	1.59/16	1.60/16	1.61/16	1.63/16	1.64/16	1.65/16	1.64/16	1.63/16	1.61/16	1.60/16	1.59/16	1.58/16

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SWAY DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.00/99	0.08/ 6	0.18/ 6	0.33/ 6	0.57/ 6	0.90/ 5	1.10/ 5	0.90/ 5	0.57/ 6	0.33/ 6	0.18/ 6	0.08/ 6	0.00/99
	7	0.00/99	0.19/ 8	0.39/ 8	0.62/ 8	0.87/ 8	1.12/ 8	1.24/ 6	1.12/ 8	0.87/ 8	0.62/ 8	0.39/ 8	0.19/ 8	0.00/99
	9	0.00/99	0.24/10	0.48/10	0.73/10	0.97/ 8	1.16/ 8	1.25/ 8	1.16/ 8	0.97/ 8	0.73/10	0.48/10	0.24/10	0.00/99
	11	0.00/99	0.25/10	0.50/10	0.74/10	0.96/10	1.12/10	1.18/10	1.12/10	0.96/10	0.74/10	0.50/10	0.25/10	0.00/99
	13	0.00/99	0.31/10	0.60/10	0.87/10	1.09/10	1.24/10	1.30/10	1.24/10	1.09/10	0.87/10	0.60/10	0.31/10	0.00/99
	15	0.00/99	0.35/16	0.68/16	0.98/16	1.21/16	1.37/16	1.43/16	1.37/16	1.21/16	0.98/16	0.68/16	0.35/16	0.00/99
	17	0.00/99	0.35/16	0.68/16	0.97/16	1.20/16	1.35/16	1.41/16	1.35/16	1.20/16	0.97/16	0.68/16	0.35/16	0.00/99

1

AMPHIBIOUS CARGO BEACHING LIGHTER THREE CONNECTED 40 FOOT MODULES

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 3.00 FEET

SURGE DISPLACEMENT
(FEET)

SIGNIFICANT VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	TO	HEAD 0	15	30	45	60	75	STBD BEAM 90	105	120	135	150	165	FOLLOW 180
0	5	0.06/ 5	0.06/ 5	0.07/ 5	0.08/ 5	0.08/ 5	0.06/ 4	0.00/ 3	0.06/ 4	0.08/ 5	0.08/ 5	0.07/ 5	0.06/ 5	0.06/ 5
	7	0.08/ 6	0.08/ 6	0.08/ 6	0.08/ 6	0.07/ 6	0.05/ 5	0.00/ 6	0.05/ 5	0.07/ 6	0.08/ 6	0.08/ 6	0.08/ 6	0.08/ 6
	9	0.08/ 8	0.08/ 8	0.07/ 8	0.07/ 8	0.06/ 6	0.03/ 6	0.00/10	0.03/ 6	0.06/ 6	0.07/ 8	0.07/ 8	0.08/ 8	0.08/ 8
	11	0.07/ 8	0.06/ 8	0.06/ 8	0.05/ 8	0.04/ 8	0.03/ 8	0.00/10	0.03/ 8	0.04/ 8	0.05/ 8	0.06/ 8	0.06/ 8	0.07/ 8
	13	0.05/10	0.05/10	0.05/10	0.04/ 8	0.03/ 8	0.02/ 8	0.00/16	0.02/ 8	0.03/ 8	0.04/ 8	0.05/10	0.05/10	0.05/10
	15	0.05/10	0.04/10	0.04/10	0.04/10	0.03/10	0.02/10	0.00/16	0.02/10	0.03/10	0.04/10	0.04/10	0.04/10	0.05/10
	17	0.04/10	0.04/10	0.04/10	0.03/10	0.02/10	0.01/10	0.00/16	0.01/10	0.02/10	0.03/10	0.04/10	0.04/10	0.04/10

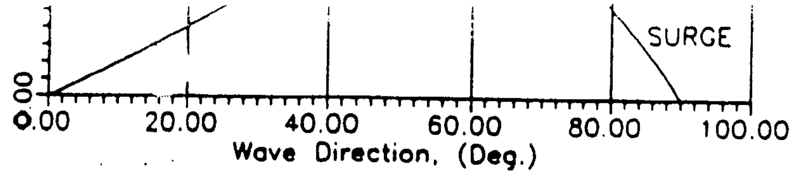


Figure B-12. Surge, heave, and sway response, sea state 2.5, 3 modules.

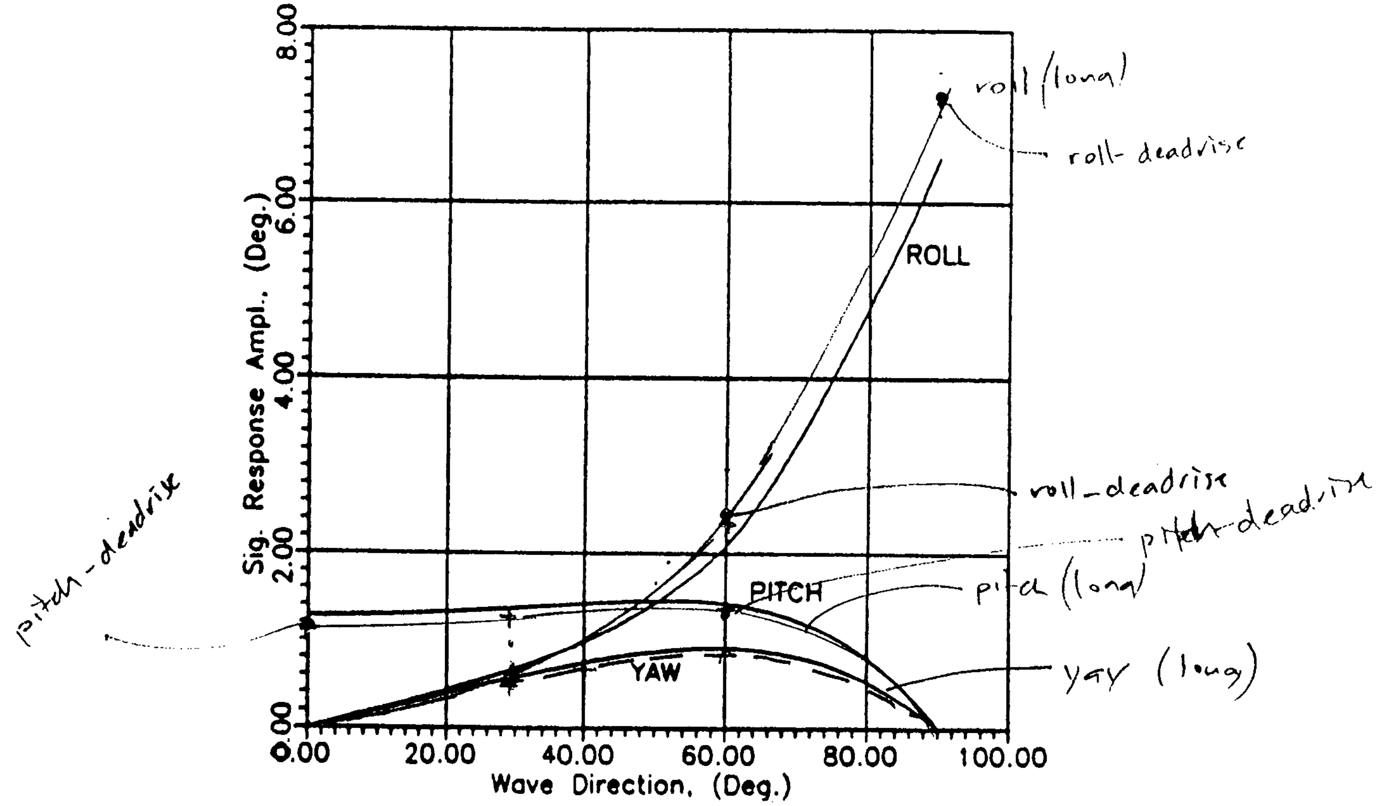


Figure B-13. Roll, yaw, and pitch response, sea state 2.5, 3 modules.

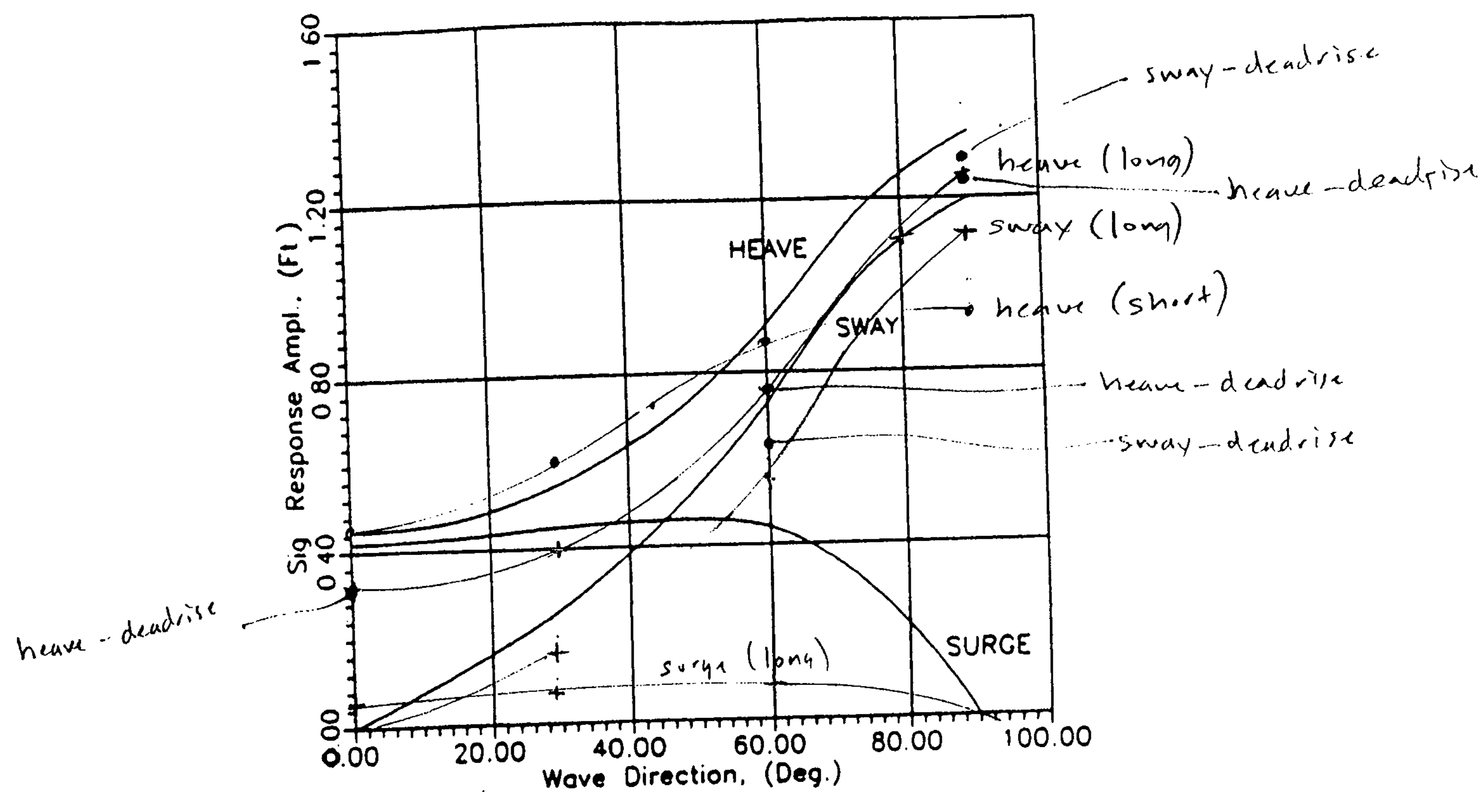


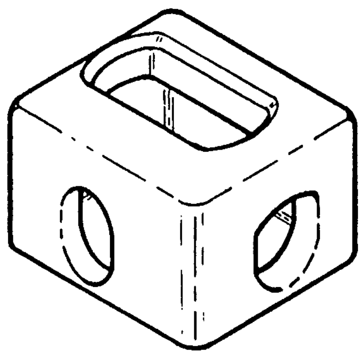
Figure B-12. Surge, heave, and sway response, sea state 2.5, 3 modules.

APPENDIX I

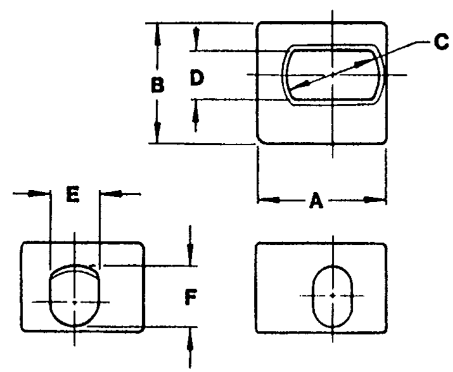
Outfit Specifications and Arrangment Drawings

NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

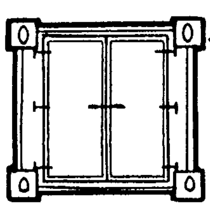
F463
CORNER FITTING
(TOP I.S.O. CORNER FITTING)



DIMENSIONAL DATA
COMMERCIAL TOLERANCE APPLIES



MODEL NO.	DIM	A	B	C	D	E	F	WT KGS. (LBS.)
F463-1	MM (INCH)	178.0 (7.00)	162.0 (6.38)	123.8 (4.87)	63.5 (2.50)	63.5 (2.50)	73.0 (2.87)	12.3 (27.0)



APPLICATION

SPECIFICATIONS

MATERIAL:
CAST STEEL

STRENGTH:
MEETS STRENGTH REQUIREMENTS OF I.S.O. STANDARD 1161

FINISH:
SELF COLORED

F463
CORNER FITTING
(TOP I.S.O. CORNER FITTING)

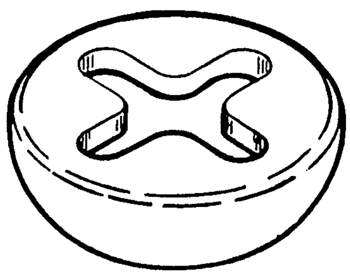
Peck & Hale
PECK & HALE, INC.
180 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

FSCM NO:94658	DRN: S.M.	SHEET OF	
DATE: 10/23/91	APPD: S.J.	2023 DWG NO	REV
SCALE: NONE	Q.C.:		

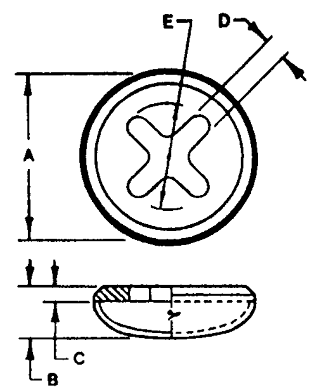
NEXT ASSEMBLY

ISSUE	REVISION RECORD	DATE	APPD

F518
DECK SOCKET
(FLUSH CLOVERLEAF)



DIMENSIONAL DATA
COMMERCIAL TOLERANCE APPLIES



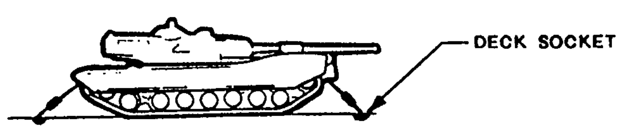
MODEL NO.	DIM	A	B	C	D	E	WT KGS. (LBS.)
F518-1	MM	317.5	85.7	19.1	44.0	209.6	- - - -
	(INCH)	(12.50)	(3.38)	(0.75)	(1.73)	(8.25)	- - - -

SPECIFICATIONS

MATERIAL:
FORGED STEEL

STRENGTH:
70,000 LBS. M.B.S. AT 45° PULL PER SLOT

FINISH:
PRIMER COATED



APPLICATION

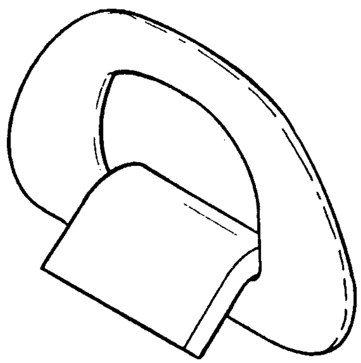
F518
DECK SOCKET
(FLUSH CLOVERLEAF)

Peck & Hale
PECK & HALE, INC.
180 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

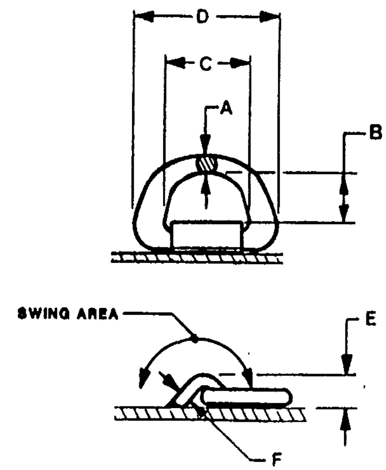
FSCM NO:94658	DRN: S.M.	SHEET OF	
DATE: 10/23/91	APPD: S.J.	3388 DWG NO	REV
SCALE: NONE	Q.C.:		

NEXT ASSEMBLY	ISSUE	REVISION RECORD	DATE	APPD

F187
D-RING & STRAP



DIMENSIONAL DATA
COMMERCIAL TOLERANCE APPLIES



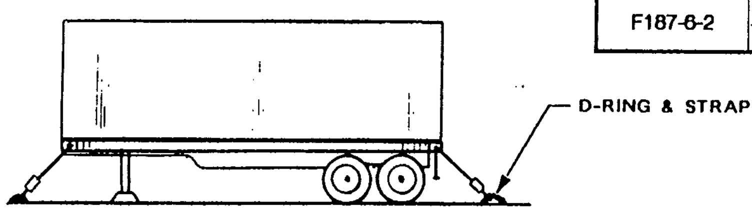
SPECIFICATIONS

MATERIAL:
D-RING: FORGED STEEL
STRAP: PLATE STEEL

STRENGTH:
7 TONNES M.B.S. PULL AT 45°

FINISH:
SELF COLORED

MODEL NO.	DIM	A	B	C	D	E	F	WT KGS (LBS.)
F187-6-2	MM (INCH)	12.7 (0.50)	41.3 (1.63)	66.7 (2.63)	123.8 (4.88)	22.0 (0.88)	6.0 (0.25)	0.5 (1.10)

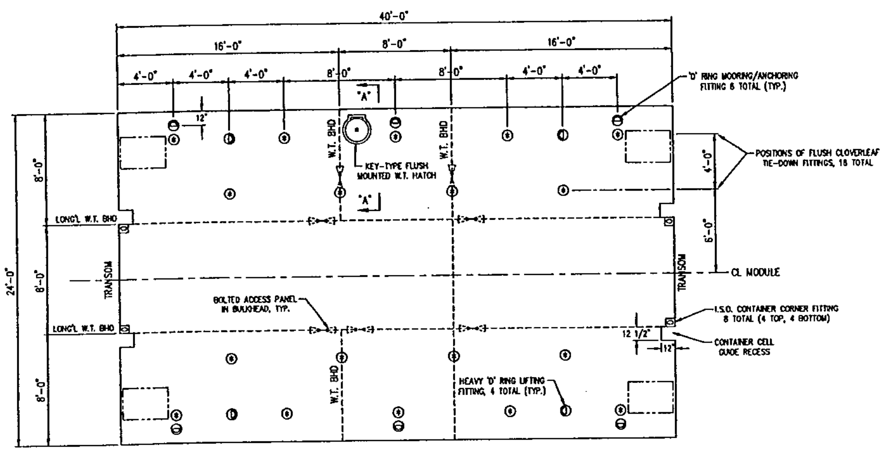


APPLICATION

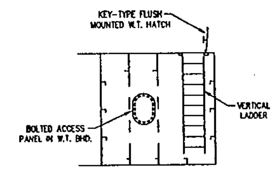
F187
D-RING & STRAP

Peck & Hale
PECK & HALE, INC.
180 DIVISION AVENUE
WEST SAYVILLE, N.Y. 11796 USA

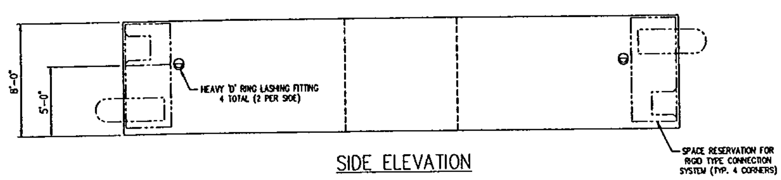
FSCM NO:94658	DRN: F.R.M.	SHEET OF	
DATE: 7/22/91	APPD: S.J.	3491 DWG NO	REV
SCALE: NONE	Q.C.:		



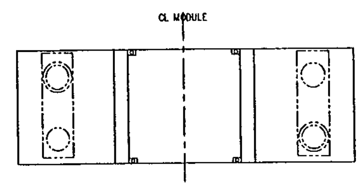
DECK PLAN



SECTION "A-A"



SIDE ELEVATION



END VIEW

NO.	REVISION	BY	DATE

Kvaerner Masa Marine Inc.

207 - 1525 West 8th Ave. Vancouver, Canada, V6J 1T5 Tel: (604) 736-8711

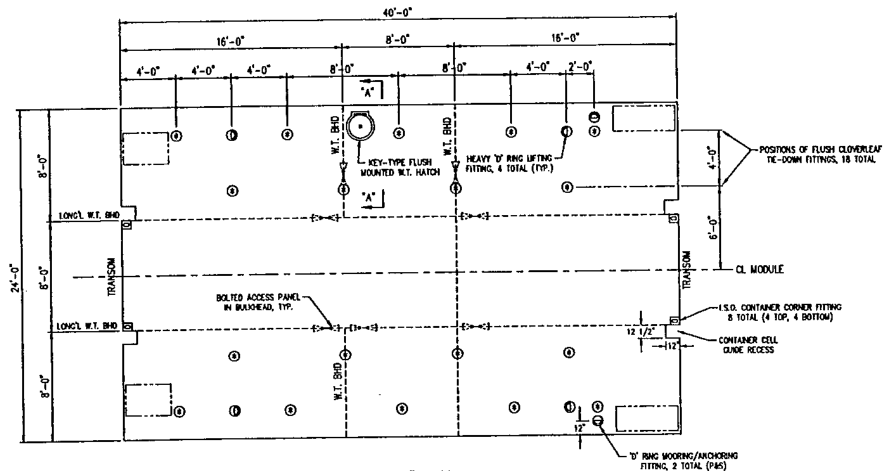
202 - 301 Defense Highway Annapolis, MD, U.S.A., 21401 Tel: (301) 970-2226

CLIENT
NAVAL FACILITIES ENGINEERING SERVICE CENTER

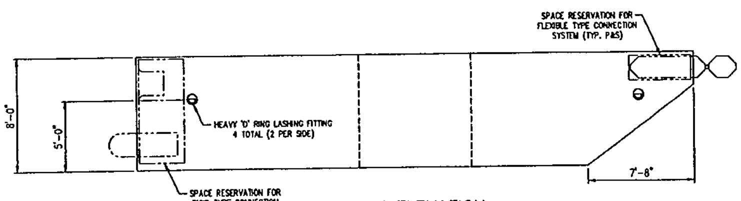
PROJECT
AMPHIBIOUS CARGO BEACHING LIGHTER

TITLE
CENTER MODULE
GENERAL ARANGEMENT

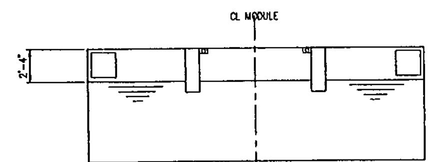
APPROVED BY	DATE			
		DRAWN: K.NG	DATE: NOV. 17/95	
		CHECK: M.D.	DATE: NOV. 17/95	
		SCALE: 1/4" = 1'-0"		
		DWG. NO. 969-000-01 SHT. 1 OF 1		REV. –



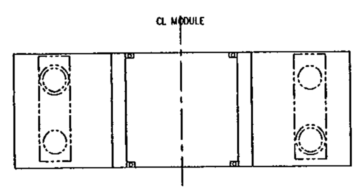
DECK PLAN



SIDE ELEVATION



VIEW ON HEADLOG



TRANSOM VIEW

NO.	REVISION	BY	DATE

Kvaerner Masa Marine Inc.

207 – 1525 West 8th Ave.
Vancouver, Canada, V6J 1T5
Tel: (604) 736-8711

202 – 201 Defense Highway
Annapolis, MD, U.S.A., 21401
Tel: (301) 970-2226

CLIENT
NAVAL FACILITIES ENGINEERING SERVICE CENTER

PROJECT
AMPHIBIOUS CARGO BEACHING LIGHTER

TITLE
END MODULE
GENERAL ARANGEMENT

APPROVED BY	DATE		
		DRAWN: K.NG	DATE: NOV. 17/95
		CHECK: M.D.	DATE: NOV. 17/95
		SCALE: 1/4" = 1'-0"	
		DWG. NO. 969-000-02 SHT. 1 OF 1	REV. –